An Ecological Study of the Vegetation of the Black Hills National Forest of South Dakota and Wyoming: A Habitat Type Classification

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INTRODUCTION

This study was done to determine and describe the forest habitat types of the Black Hills National Forest.

Objectives

The objectives of this study were the following:

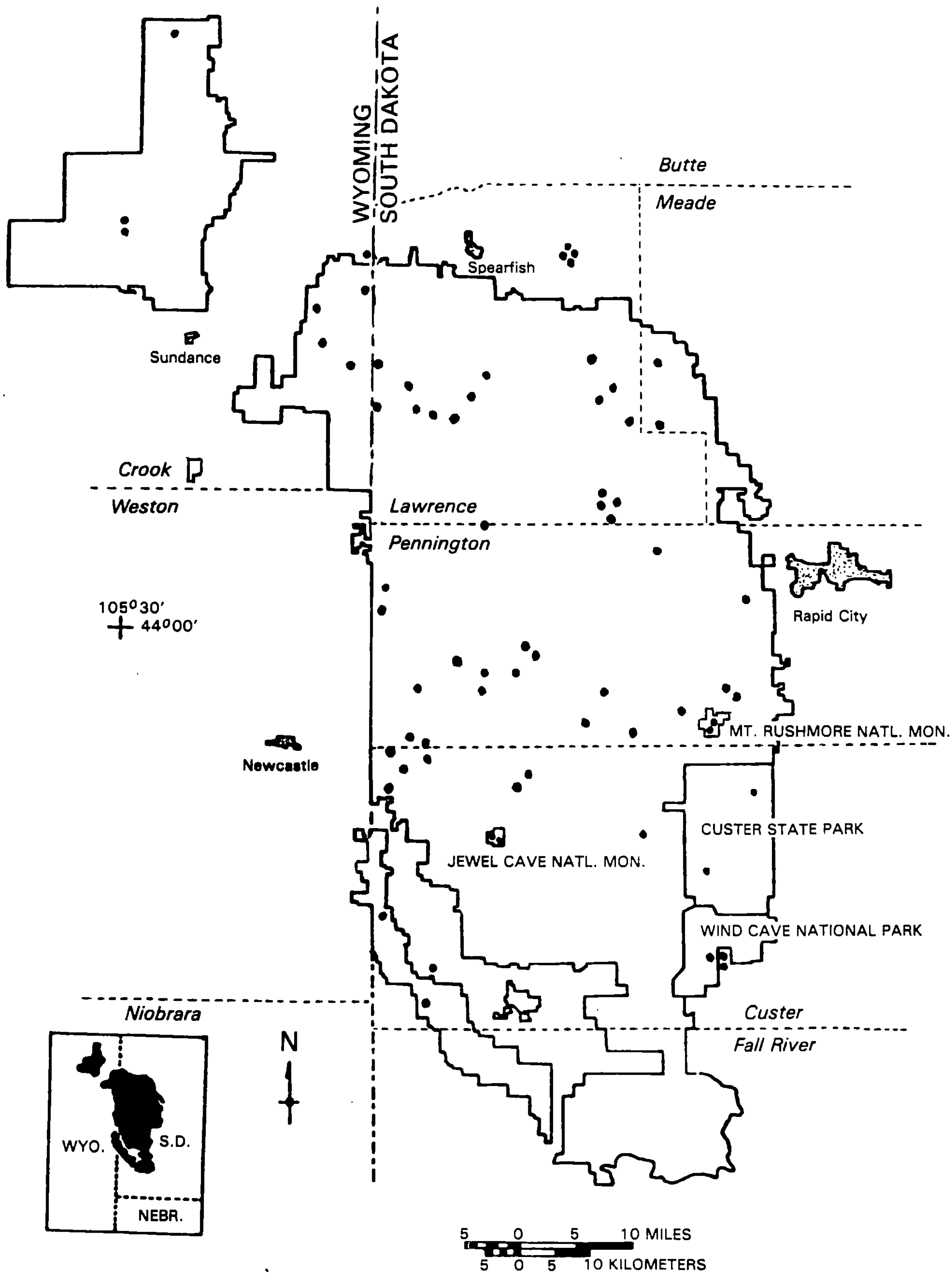
1. On the basis of both reconnaissance and intensively sampled plots, determine and describe the forest habitat types of the Black Hills National Forest (Figure 1).

2. To the extent possible, relate the habitat types to soils and climate of the region.

3. Evaluate the relationship of the Black Hills habitat types to those similarly studied in surrounding areas.

Figure 1. Map of the Black Hills National Forest showing locations of stands intensively sampled. Parks and Monuments of the region are also shown.

BLACK HILLS NATIONAL FOREST



The Classification of Forest Vegetation and Lands

At least since the days of Alexander von Humboldt, botanists have shown interest in the ecological distributions of plants; and it was natural that there would develop classifications of plant formations. Initially physiognomy was the primary basis for classification systems. This was surprisingly adequate for numerous purposes, and still plays a role in current descriptions of plant communities. With greater understanding of vegetation as an entity to be studied, and managed, classifications evolved to match the level of understanding. The value of any classification system in science is in organizing knowledge and allowing maximum predictions about any unit in the classification scheme. If it exists, such a system is a natural one. In vegetation science the closest to a natural system is one in which the name of the unit (in this case habitat type) alone is meaningful in predicting succession, indicator species, biotic potential, edaphic factors, animal life, etc.

With greater emphasis on vegetation dynamics, foristics, the meaning of dominance, and recognizing the unequal roles of species in communities, classifications began to take into account these aspects of plant communities.

After years of intensive study of northern Rocky Mountain vegetation, Daubenmire (1952) developed a system of classification which is closest to natural of any so far in use. Daubenmire (1952) showed that even though most units of land

support disturbed vegetation, it is possible to evaluate successional trends and predict the climax vegetation (plant association) for the same units of land. In so doing, he also classified the sites as _habitat types_. Thus, a habitat type is represented by those land areas which support, or will come to support, in the absence of disturbance, a particular plant association. The vegetation therefore is used in naming habitat types.

The terminology for climax vegetation follows to some extent that of Tansley (1935). _Climatic climax_ vegetation is that which occupies and perpetuates itself on fairly deep, well-drained soils of normal topography. _Edaphic climax_ vegetation differs from climatic climax and perpetuates itself as a result of unusual edaphic factors. _Topographic climax_ vegetation also differs from climatic climax and perpetuates itself as a result of the strong influence of topography. These climax types are _primary climaxes_ and are the basis for habitat type evaluation. _Fire climax_ and _zootic climax_ vegetation types are self-perpetuating, and are distinctive as the result of periodic fires and intense grazing respectively. In the nomenclature, these are referred to as _disclimaxes_ and if the influences of fire and grazing were removed, they would theoretically change in the direction of one of the primary climaxes. This assumes that the fire and grazing disturbances have not been so severe as to drastically alter the intrinsic habitat characteristics or destroy the

flora that makes up the vegetation. Disclimaxes are not the bases for classifying habitat types.

In classifying forest vegetation, the multilayered structure of the communities is also important. The overstory dominant layer usually is most influential in controlling the microclimate of the stand. This in turn controls the occurrence of some, but not all the undergrowth species. In general, undergrowth species are distributed fairly independently of overstory species. In the structure of plant communities, the *union* is the smallest unit. It can consist of only one species which has a distinctive ecology, or it can consist of several (to many) species which have rather similar ecologies, and similar distributions. In the *Populus tremuloides* zone of western Colorado, for example, Populus is the dominant species and sole member of the *Populus tremuloides* union, and it is dominant in several habitat types there. Over much of the range, the undergrowth consists of the *Thalictrum fendleri* union, rich in species of mostly herbaceous forbs. The specific composition of the Thalictrum union varies from stand to stand, but overall it can be recognized by the mixture of plants of high constancy, high overall coverage, and ranging in height from 2 dm to 15 dm. Sites supporting this vegetation are the *Populus tremuloides*/*Thalictrum fendleri* habitat type. Over the Populus zone other habitats support a vegetation closely similar in flora, but in which *Heraclum sphondylium* dominates

in the undergrowth. Heracleum may be 2 m tall, provide 80-100% coverage and essentially mask the presence of the Thalictrum union. Heracleum sphondylium is a single-species union, distinct in its distribution and physiognomy. In these habitats, under the Heracleum, one finds numerous members of the Thalictrum fendleri union. Indeed, in sampling such dense stands it is often necessary to cut off the Heracleum after estimating its coverage to view what occurs beneath. When this is done one observes the Thalictrum union quite well represented. The same procedure is necessary in stands of the Populus tremuloides/Pteridium aquilinum association. Here, removing fronds of Pteridium also reveals the Thalictrum union underneath. Over the range of distribution of the Populus/Thalictrum association so far described in western Colorado, the floristic differences among stands appear to be random, not clinal. This is an important point and will be discussed more fully below.

The concept of the habitat type is basic ecology; as such it offers for forest vegetation a natural classification scheme which satisfies the needs of both the ecologist who may be interested primarily in the theoretical aspects of vegetation science and the forester who may be interested in theoretical aspects but also concerned with the practical uses of such a classification. Habitat types have been shown to have predictive value for tree growth rates (Daubenmire 1961), susceptibility of trees to insect attack and mistletoe infection, potential for producing browse species following fire, depth of soil

moisture drought during the summer, and tree species regeneration (Daubenmire 1973, 1976; Arno and Pfister 1977; Layser 1974; Pfister 1972).

In earlier reports (Hoffman and Alexander 1976, 1980, 1983), we grouped habitat types dominated by the same tree species into series of the same name, e.g. Pinus ponderosa Series, Populus tremuloides Series, etc. The Series provides a thread of continuity among habitat types dominated by the same climax tree species. The ecological basis for this level in the classification hierarchy is the influence of macroclimate. Even without empirical data, it seems a safe assumption that trees are influenced more in their distributions than undergrowth species by the macroclimate. Thus, the presence in various locations of self-perpetuating populations of a tree species, e.g. Pinus ponderosa, indicates closely similar macroclimates of those areas. The undergrowth of these stands is controlled more by edaphic and topographic characteristics.

The nomenclature for habitat types is binomial; the dominant overstory species is combined with the name of the major undergrowth union. Thus, as indicated above, Populus tremuloides / Thalictrum fendleri is the name given to the particular association and to the habitat type. As in species taxonomy, habitat type taxonomy is best kept simple. The binomial system indicates the climax dominant and the name of the predominant climax undergrowth union. More description than this is unnecessary for nomenclatural purposes. The point

of the nomenclature is to name the habitat types in a systematic manner. Obviously, more information about each habitat type is present than can be given in the name. But it is no more necessary or appropriate for the name to be more complicated than the name of a plant. Certain it is that most plant species are identified by characteristics not at all given in the name, but that is insufficient reason to change the binomial system of nomenclature. A plant species may be identified by its flower color, number of carpels, number of stamens and whether included or exserted, etc. A habitat type may be identified by such characteristics as species make up of the overstory, species of the undergrowth and perhaps coverage characteristics. These are not reasons to complicate the habitat type nomenclature. For example, should the name of the Populus tremuloides/Thalictrum habitat type also include Geranium richardsonii as another important forb and Carex geyeri as a characteristic graminoid, it could lead to unnecessary complications. It could lead to constraints on the habitat type we do not currently accept. One must keep in mind that very few species show 100% constancy for any given habitat type. The more species we add to the name of a given habitat type, the more someone in the field will expect to find each species listed to verify the habitat type identification.

At the present stage of knowledge or refinement, in understanding habitat types, constraints are to be added conservatively or the progress made in classifying vegetation and landscapes

could be slowed or reversed under the sheer weight of limitations, constraints, and perhaps new terms to designate all the limitations and constraints.

Literature Review

The concept of habitat types was put forth by Daubenmire in 1952. In 1968 Rexford and Jean Daubenmire published their comprehensive study on the forest habitat types of eastern Washington and northern Idaho. Since then a broad effort has been made to classify the forest habitat types throughout the Rocky Mountain region; this has been sponsored by the U. S. Forest Service. Some areas have been studied more intensively and extensively than others. In addition to the work done by the Daubenmires in eastern Washington and northern Idaho, habitat type studies have been done in Montana (Pfister et al. 1977), Wyoming (Hoffman and Alexander 1976; Reed 1971, 1976; Wirsing and Alexander 1975), Colorado (Moir 1969; Steen and Dix (cited by Alexander 1974); Hoffman and Alexander 1980, 1983), Idaho (Steele et al. 1981), eastern Idaho and western Wyoming (Steele et al. 1983), New Mexico and Arizona (Moir and Ludwig 1979; Hanks et al. 1983; Alexander et al. 1984a, 1984b), and Utah (Mauk and Henderson 1984).

Habitat types of the Black Hills have not been studied previously, though a number of plant collections have been made there; and several vegetation studies have also been

done there. Additionally the U. S. Forest Service has conducted numerous studies in the Black Hills related primarily to the management of Pinus ponderosa.

Plant collections have been made in the Black Hills since the early 1800's. Various plant collectors accompanied early military and geological expeditions (Hayden 1869, Custer 1874, Ludlow 1875, Newton and Jenny 1880). Rydberg (1896) was the first to do a concentrated study on the Black Hills flora; he identified 688 species. Following these early efforts, others continued to collect plants to develop a complete flora of the region. Buttrick (1914) discussed the origins of the Black Hills flora as the region supports species of northern, Rocky Mountain, eastern and transcontinental affinities.

Hayward (1928) and McIntosh (1930, 1949) described the vegetation and some of the successional sequences as they interpreted them. Both described vegetation types generally and used terminology characteristic of Clements. These reports are significant only as historical documents providing a record of plants collected and the general nature of vegetation present.

More recently Thilenius (1972) and Severson and Thilenius (1976) described in somewhat more detail vegetation types in the Black Hills. Thilenius (1972) sampled along transects established previously by the South Dakota Department of Game, Fish, and Parks to estimate numbers of deer in the Black Hills.

A definite drawback was the lack of choice in determining sample sites. Sampling on areas previously selected for deer pellet studies would seemingly limit the possibility of producing vegetation data that expresses biotic potential of an area. By chance alone, a few sites may have been near climax, but photos published by Thilenius (1972) show clearly that his sample sites were hardly selected for maturity of the overstory. As a result, his "habitat units" would coincide only coincidentally with habitat types of the same region. Severson and Thilenius (1976) classified aspen stands in the Black Hills and Bear Lodge Mountains. Their random selection of sample sites and virtual lack of successional interpretations leaves only correlational information among plants and abiotic factors. For strict inventory purposes for 1976 the approach may have been suitable.

STUDY REGION

Physiography and Geology

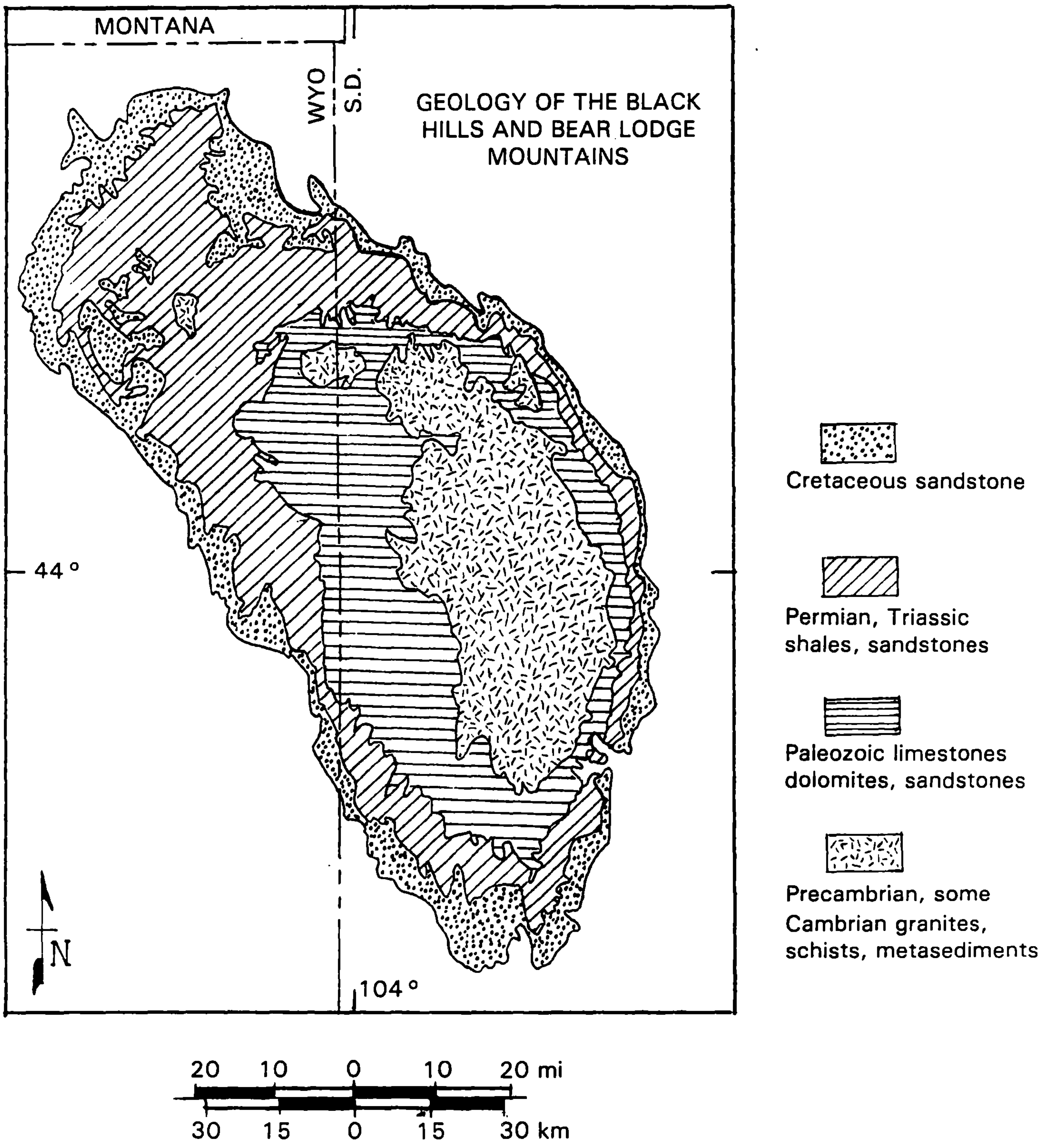
The Black Hills are located on the Missouri Plateau of the Great Plains Province (Fenneman 1931). These mountains are a maturely dissected domal uplift with a central crystalline core surrounded by steeply dipping sedimentary deposits. The Hills are about 200 km north to south and 100 km east to west. Harney Peak in the central core is the highest peak at 2207 m. Seven other peaks are 1829 m or higher. The plains that surround the Hills are 915 m to 1065 m in elevation. Four sections of the Hills are distinct in geomorphic characteristics: (1) central core of granitic and metamorphic rocks; (2) limestone

plateau which surrounds the central core; (3) red valley which nearly encircles the Hills, but is best developed on the east side; and (4) hogback ridge just outside the Red Valley (Darton and Paige 1925).

The central core is Precambrian granites, schists, and metasediments and is located somewhat east of center of the domal structure. Following uplifts this core was exposed by erosion of the overlying sedimentary deposits over vast periods of time. Though domal uplift of the Hills apparently began over 600 million yr b.p. and occurred intermittently for about 500+ million years, the major uplift occurred sometime between late Cretaceous and early Tertiary. A final uplift during late Tertiary and early Quaternary left the Hills with their present configuration (Thornbury 1954, Figure 2).

The central core area is characterized by broad valleys, mountain peaks and canyons. In addition to Harney Peak, others of size in this area are Bear Mountain, 2184 m, Terry Peak, 2155 m, and Custer Peak, 2071 m. The soils of this area are generally coarse, thin on the slopes and higher elevations, and usually acidic.

The limestone plateau surrounding the central core consists of limestones, dolomites, and sandstones of early to late Paleozoic. It is most prominent and broader in the northwestern part of the Hills where in places it is 30+ km across. Over much of its area, it is nearly level and somewhat higher elevation than much of the central core area. On the east side of the Hills the plateau is much reduced in size and becomes more of


MONTANA
WYO
S.D.
GEOLOGY OF THE BLACK HILLS AND BEAR LODGE MOUNTAINS
44°
104°
N
20 10 0 10 20 mi
30 15 0 15 30 km
Cretaceous sandstone
Permian, Triassic shales, sandstones
Paleozoic limestones dolomites, sandstones
Precambrian, some Cambrian granites, schists, metasediments

a homoclinal ridge. Soils of the limestone plateau are relatively fertile, and fine-textured.

The red valley is outside of the limestone plateau, and encircles the Hills. It is derived from red shales of the Permian and Triassic Spearfish formation. It is essentially a nonforested valley, about 3.0 $\pm$ km in width between the more gentle backslope of the limestone plateau and the sharply dipping escarpment of the Dakota hogback. The approximately 200 m thick layer of Spearfish sands and shales, between the heavy limestone below and the Dakota sandstones above, are fairly nonresistant to weathering, and they formed a valley of substrates more suitable for steppe vegetation. The soils are fine-textured and generally deep.

The Dakota hogback forms the outer rim of the Hills. Its inner face rises abruptly above the red valley and its backslope tapers gradually to the plains outside the Black Hills proper. It is formed from sandstone of Cretaceous age. Soils on the inner face are coarse-textured, those on the outer slope (backslope) are fine-textured due to the influence of Pierre Shale there.

The Bear Lodge Mountains, northwest of the Black Hills, are also a domal structure much smaller in size. The high elevation is Warren Peak at 2029 m. The sedimentary rocks there are the same as indicated for the Black Hills.

In general, the soils of the Black Hills are classified as "gray wooded" (Radeke and Westin 1963).

Climate

In the northern Great Plains, the climate surrounding the Black Hills is that of a midcontinental grassland. Winter temperatures are low and summer temperatures are high (Figure 3). Annual precipitation of the immediately surrounding plains ranges from 340 mm to 462 mm (Figure 4, Table A-12). Ardmore, Hot Springs, New Castle, Sundance, Belle Fourche and Rapid City surround the Black Hills and are somewhat representative of the continental climate indicated above. They receive 70-80% of their precipitation during the six warm months of the year, and record their highest and lowest mean temperatures in July and January respectively. Most weather stations within the Black Hills record more than 500 mm precipitation annually. Two exceptions in Table A-12 are Deerfield and Custer with 459 mm and 437 respectively. Additionally, among the stations in the Black Hills, precipitation during the six warm months ranges from 60% to 73% of the total, indicating these stations receive a larger proportion of the annual precipitation during the six cool months than do the surrounding plains. Mean temperatures of the Black Hills are generally higher in the winter and lower in the summer than most of the surrounding Great Plains stations. Also, yearly temperature extremes are generally less in the Black Hills than on the surrounding plains. January means at Lead and Deadwood, for example, are -4.8°C and -4.4°C respectively, while those at Ardmore and Sundance are -7.00°C and -7.61°C. July means at Lead and Deadwood are 19.8°C and 19.6°C respectively. The same monthly means at Ardmore and Sundance are 23.3°C and 22.9°C.

Figure 3. Climate diagrams of stations in and close to the Black Hills.

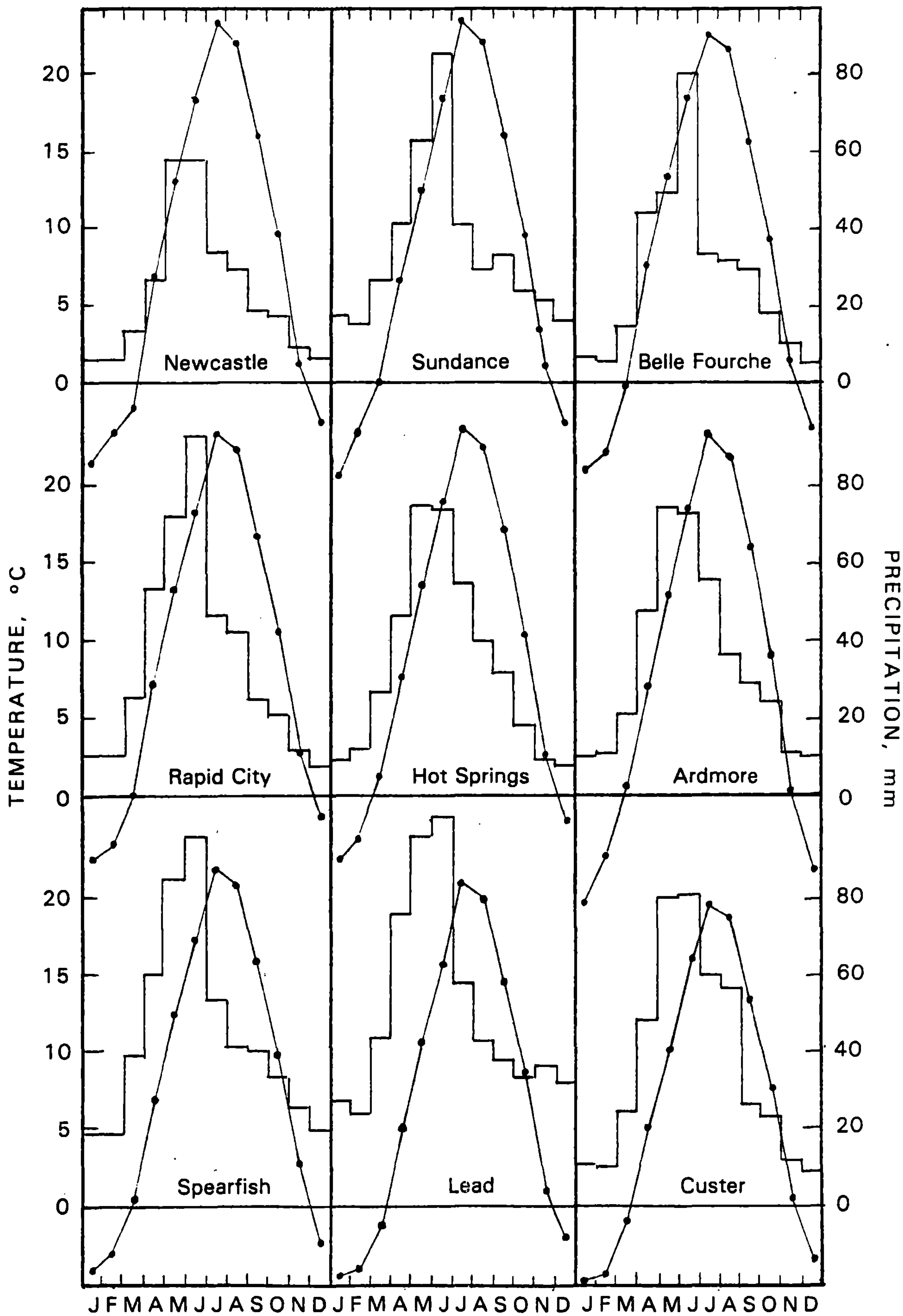
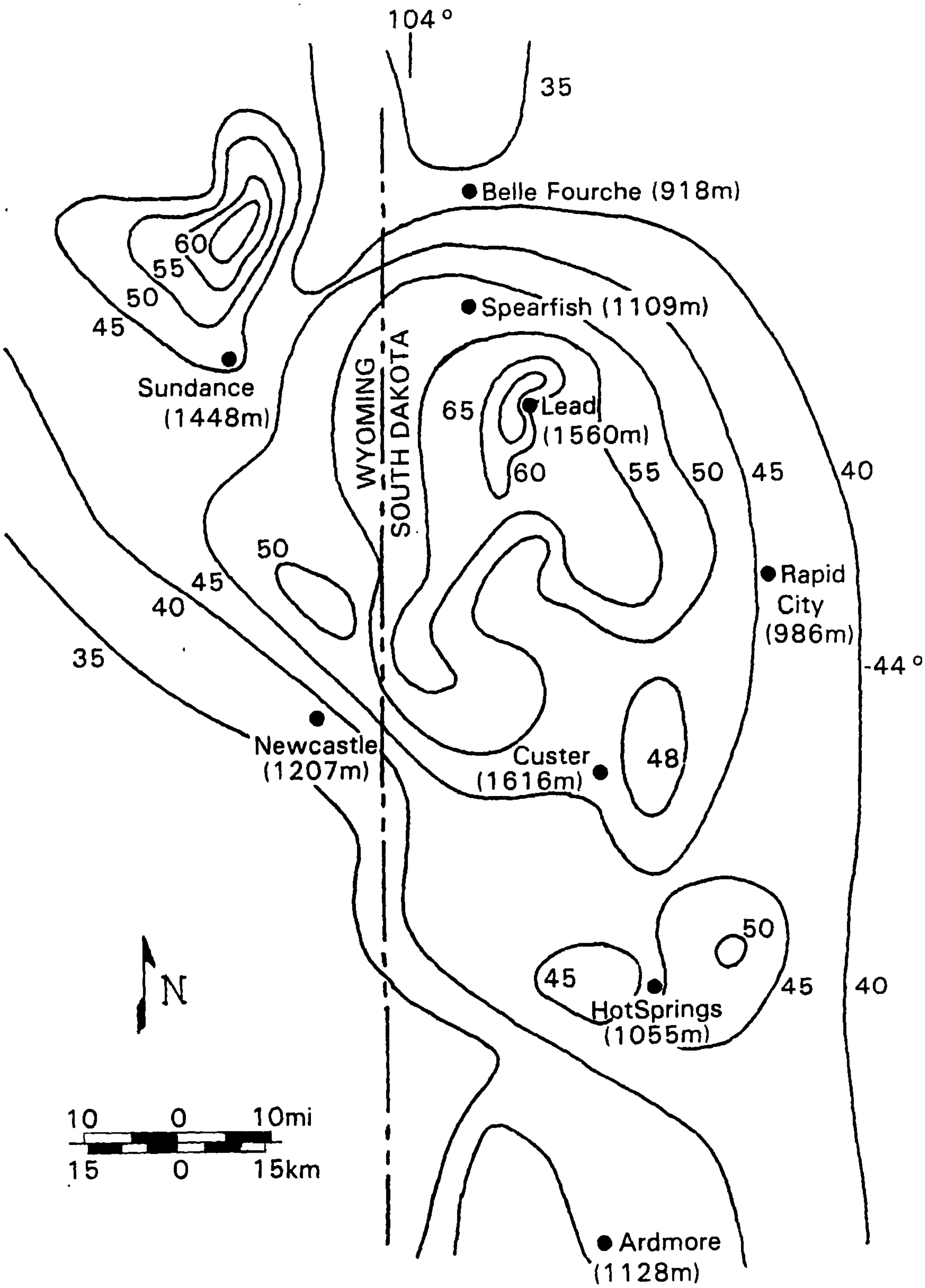

Newcastle
Sundance
Belle Fourche
Rapid City
Hot Springs
Ardmore
Spearfish
Lead
Custer
TEMPERATURE, °C
PRECIPITATION, mm
0
5
10
15
20
0
20
40
60
80
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D

Figure 4. Isohyets of annual precipitation, in cm, in the Black Hills region.


104°
35
Belle Fourche (918m)
60
55
50
45
Sundance
(1448m)
Spearfish (1109m)
WYOMING
SOUTH DAKOTA
65
Lead
(1560m)
60
55
50
45
40
50
45
40
35
Rapid
City
(986m)
-44°
Newcastle
(1207m)
Custer
(1616m)
48
50
45
HotSprings
(1055m)
45
40
N
10 0 10mi
15 0 15km
Ardmore
(1128m)

These four stations illustrate the differences, though other station data are available to illustrate exceptions to the general statement.

The northern half of the Black Hills ordinarily receives more precipitation than the southern half and is typically cooler. How much this difference influences vegetation patterns will be discussed below.

The Black Hills are small in both areal extent and elevation compared to the massive blocks of mountains which make up the main chain of the Rockies. Forests in the Black Hills extend from approximately 1200 m to about 2100 m, a span of 900 m. Forests in the Colorado Rockies occur from approximately 1800 m to 3200 m, an elevational range great enough to reveal a well-defined climatic gradient from warm, dry low elevation forests to cool, moist upper elevation forests. The belts of forest are arranged perpendicular to the nearly vertical gradient in climate. In the Black Hills the warm, dry environments of low elevations, which support *Pinus ponderosa* forests are especially conspicuous in the southwestern corner of the Hills. Along the northeastern perimeter of the Hills, at slightly higher elevations, the environments are more moist and support *Pinus ponderosa* forests with considerably richer undergrowths. *Pinus ponderosa* forests extend upward to elevations of 2000 - 2100 m which overlap the *Populus tremuloides* zone and match the upper extent of *Picea glaucus* forests. Thus, the zonation of vegetation in the Black Hills

is less conspicuous as a result, in part, of a weaker climatic gradient from low to high elevation based on a rather small mountain mass. Complex topography, variable wind patterns, transfers of moisture, and various depths of snow pack and times of melting, and other results of exposure and elevation all tend to obscure simple and direct relationships between elevation and temperature or precipitation in the Black Hills.

Climax vegetation, or that in late stages of succession, is a valuable indicator of site potential. Because site potential necessarily includes climate as a controlling factor, the same vegetation may be a useful key to macro- or microclimates of the sites. It is uncertain at this point how valuable are the available climatic data in relation to vegetation patterns in the Black Hills, except in a very general way.

METHODS

This study was begun in 1982 when I traveled throughout the Black Hills National Forest to visit about 200 reconnaissance sites. At each site I recorded the species and general size class distribution of the tree population(s). I attempted to evaluate the successional status of the vegetation and list what appeared to be possible useful indicator species. Also, I collected plants at each site and recorded the elevation, slope and exposure. Where possible I noted the geologic parent material and soil texture of the upper dm. Finally, I noted the presence or damaging influence of pests, if evident, and general condition of the stand.

It is necessary to locate the old stands of timber. This was challenging in the Black Hills where intensive management has occurred for so long that much of the forest land supports young to medium-aged forests. Few areas in the Hills[1] are inaccessible, and management has extended widely over the region. Finally, the demand for timber plus the devastation of widespread fires during the early days has further reduced the number of sites supporting older stands of timber.

During the first field season I examined stands over the entire extent of the Hills so that the variation in the habitat types across the extent of the Hills would be detected. Following the first field season I checked plant identifications and compiled a list of tentative habitat types. The list would be verified and/or altered as detailed stand data were accumulated during the second and third years of the study.

In 1983 and 1984 I sampled intensively a number of the reconnaissance sites of 1982 plus additional sites I considered suitable for sampling. Greater exposure to and familiarity with the region and its vegetation during the second and third field seasons is invaluable. The sampling of individual sites and continued reconnaissance throughout the second and third seasons is the best way by which feedback from one activity provides direction for the other activity. The end result is the most comprehensive analysis of habitat types possible in

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[1]For brevity the term Hills will be used throughout the remainder of this report and will include all the Black Hills and the Bear Lodge Mountains included in this study.

the time available for the study.

At each site selected for study I determined subjectively the most homogeneous part of the stand where I laid out a 15 x 25 m plot using stakes to mark the corners and string to delimit the perimeter. I tried to include the largest tree of each stand as long as it was not adjacent to a game trail, an ecotone, or other disturbed area. On hills the plots were placed parallel to the contours of the slopes to maximize the probability of remaining within a single soil type. Under the constraints given, the method assured sampling within an old part of each stand. This no doubt resulted in overestimating the age and basal area of the tree population(s), but the bias was consistent, and data are comparable from stand to stand. With two 25 m tapes I subdivided the plot into 3 macroplots 5 x 25 m each. Within each macroplot I recorded into dm diameter size classes every tree taller than 1 m. Stand basal area was calculated on the basis of midpoints of the tree size classes then expressed as m^2/ha. Within two 1 x 25 m transects placed along the inner sides of the central macroplot, I counted and recorded all tree seedlings less than 1 m tall. This number, based on a 50 m^2 sample, was converted upward to represent the 375 m^2 overall plot size. Tree population data of this study are listed in Appendix Table A-1. Elevation, slope and aspect were all recorded at a point near the center of the 15 x 25 m plot.

I sampled canopy coverage of undergrowth species within 50 2 x 5 dm microplots placed systematically at meter intervals along the inner sides of the central microplot. I used the method of Daubenmire (1959) to record these canopy coverages:

Coverage Class	Coverage Interval	Coverage Midpoint
1	1 - 5%	2.5 %
2	6 - 25%	15.5 %
3	26 - 50%	38.0 %
4	51 - 75%	63.0 %
5	76 - 95%	85.5 %
6	96 -100%	98.0 %

In the field coverage class numbers are recorded for every species within every microplot. The microplots are small, 0.1 m^2; the coverage intervals are rather large, and 50 microplots are sampled in each stand. All these contribute to obtaining adequately accurate coverage estimates for every species present. Later the coverage class designations are converted to the coverage range midpoints which are used to calculate coverage of each species in each stand. Frequency and constancy are calculated from the same set of coverage data. Coverage and frequency data for this study are recorded in Appendix Tables A-2 through A-10.

At each stand I collected at least 25 soil samples from the upper 1 dm of the mineral soil. These were composited in the field in a paper sack, air-dried, then taken to the laboratory for analysis. After they were screened through a 2 mm sieve, the soils were tested for pH (glass electrode and saturated soil paste), exchangeable Ca and Mg (EDTA titration method), K and P (bicarbonate extraction method), pH lime

requirement (Ohio SMP Method), cation exchange capacity and base saturation (by addition), organic matter (dichromate method) and particle size distribution (modified Bouyoucos method in Moodie and Koehler, 1975).

In Cercocarpus-dominated stands, numbers 35, 36, 56, where the dominant shrubs were 1.5 to 2 m tall, I measured canopy coverage of the dominant shrub along a 50 m tape by recording canopy intercept of the tape placed at the average height of maximum canopy spread. The tape was stretched along the contour of the slope and through the most representative part of the stand, as determined subjectively. Expressed as the percentage of total line (tape) length, the intercept is the coverage and is comparable to that estimated within two dimension sample plots (Daubenmire 1968). In the same stands the 50 2 x 5 dm microplots for undergrowth canopy coverage estimates were placed at 1 m intervals along the tape (Daubenmire 1970).

Soil samples were collected within 0.5 m either side of the tape along its length in the stand. These were treated the same as indicated for other soil samples. Elevation, slope, and aspect were all recorded at a point near the center of the 50 m transect.

All plants in this study were identified to species, where possible. Nomenclature follows Van Bruggen (1976). There were few taxonomic curiosities. Those encountered resulted mainly from a lack of flowering or fruiting specimens. Those, also, were not abundant and not widespread. It is possible some hybridization was encountered. <u>Osmorhiza</u> <u>depauperata</u>, <u>O</u>. <u>chilensis</u>, and <u>O</u>. <u>longistylis</u> occur and were identified. An

occasional specimen of Osmorhiza was encountered that did not fit easily into any of these species, or any other species for this region. There were minor problems with Allium, Viola, and Carex, particularly on certain sites where they appeared to be growing poorly and producing no flowers. The vegetative forms of *Fragaria virginiana* and *F. vesca* overlapped and were not possible consistently to separate. Some of the Ribes species proved difficult to identify in certain locations. *Ribes oxyacanthoides* and/or *R. setosum* could not be distinguished in all places, and certain *R. lacustre* appeared to me to be very close to *R. oxyacanthoides*.

HABITAT TYPES

Cercarpus montanus Series

The *Cercocarpus montanus* Series is one of two in this study not represented by forest vegetation. *C. montanus* is a shrub, up to 2 m tall at maturity in the Hills, which dominates shrub-steppe vegetation. It occurs at low elevations, on xeric sites around the southern one-third of the Hills. In the southwestern part of the Hills well-developed stands may be found southeast of New Castle, Wyoming, and on fairly steep hillsides in Boles, Redbird and Hells Canyons (Figure 5). The vegetation is patchy in occurrence, and does not form a continuous zone around the southern perimeter of the Hills. *C. montanus* is an important shrub in the chaparral of the southwest. In the Hills it is at the northern and easternmost limit of its distribution and the vegetation it dominates has the physiognomy of chaparral.

In the Hills Cercocarpus stands contact *Pinus ponderosa* dominated vegetation above and steppe or shrub-steppe below.

Figure 5. View across Boles Canyon in the southwestern Black Hills showing Cercocarpus montanus-dominated community on steep slope of coarse-textured substrate.

Cercocarpus montanus/Bouteloua curtipendula habitat type.---This is the only _C. montanus_-dominated h.t.[2] in the Hills. Three stands were sampled; they range in elevation from 1,265 m to 1,493 m. All stands are on hillsides with slopes of 21% to 38%. Direction of exposure apparently is not a limiting factor within the vegetation zone.

Cercocarpus montanus dominates the overstory of this association. It has coverage values of 41% to 45%. _Rhus aromatica_ is a smaller-statured shrub with coverages of 1.7% to 8.4%, and is a constant member of this association. Total shrub coverage is 49 – 55%. Cercocarpus and Rhus are rather evenly spaced with herbaceous species and low-growing shrubs occupying the spaces among the tall shrubs (figure 6). An occasional _Pinus ponderosa_ or _Juniperus scopulorum_ occurs in stands of this h.t. but neither appears to be increasing its numbers. Somewhat less xeric habitats represent ecotonal areas where Pinus is more abundant and Cercocarpus somewhat less abundant. _Bouteloua curtipendula_ dominates the undergrowth; its coverage ranges from 24% to 37%. Species composition is relatively sparse with fewer than 20 species sampled in any one of the stands. Most of the undergrowth species also occur in the adjacent steppe vegetation; those with a constancy of 100% and their coverage values are as follows:

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[2]For brevity h.t. will be used in various places for habitat type; h.ts. is the plural form.

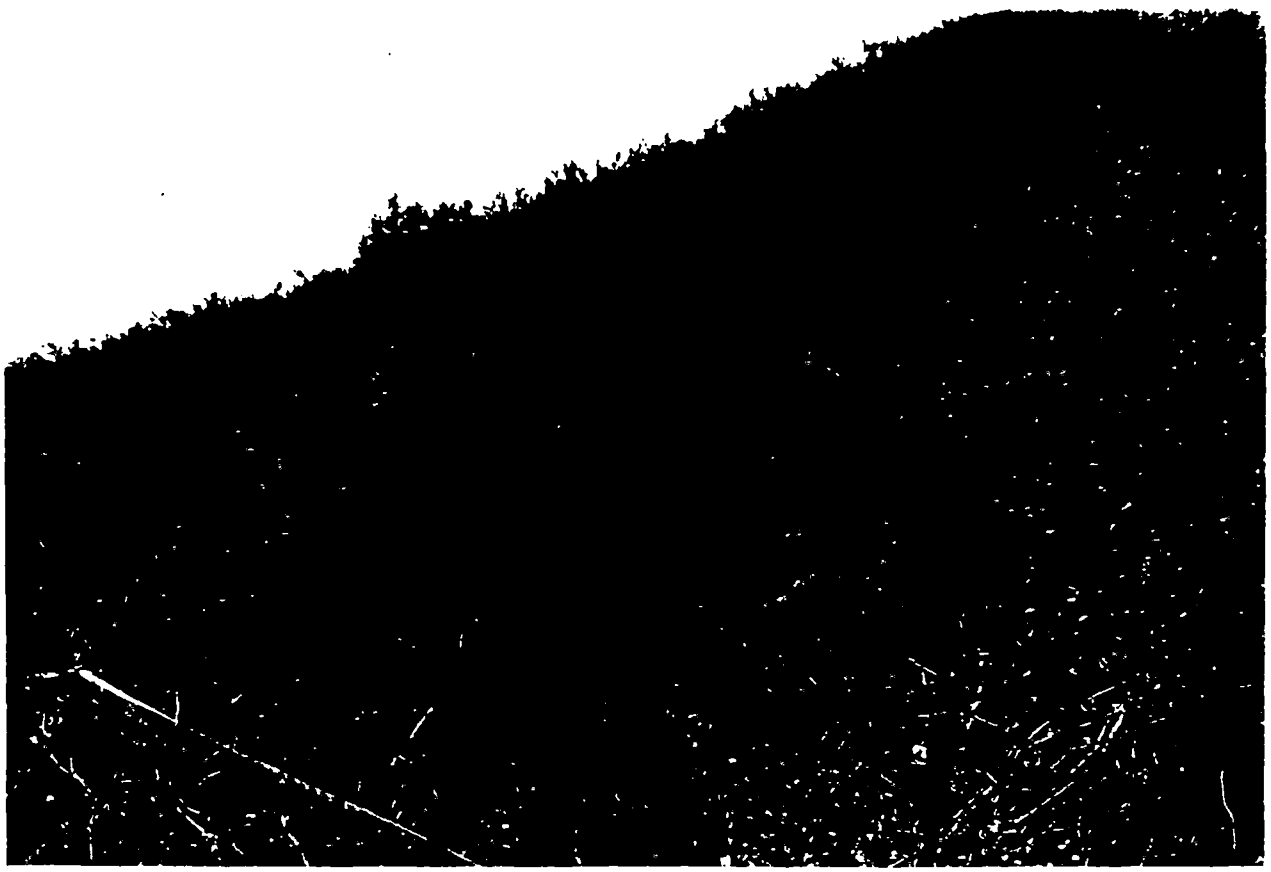


Figure 6. Stand 55, Cercocarpus montanus/Bouteloua curtipendula habitat type. The meter stick in this and subsequent photos is marked in dm segments.

Species	Constancy	Mean Coverage
<u>Aristida longiseta</u>	100%	1.41%
<u>Artemisia frigida</u>	100	0.90
<u>Aster oblongifolius</u>	100	1.40
<u>Bouteloua curtipendula</u>	100	30.00
<u>Hedeoma hispida</u>	100	2.27
<u>Oryzopsis hymenoides</u>	100	1.60
<u>Sitanion hystrix</u>	100	2.08

Coverage and frequency of all plants sampled in this h.t. are presented in Appendix Table A-2.

Though combinations of undergrowth species differ, <u>Cercocarpus montanus</u>-dominated communities occur over considerable areas of the Rocky Mountain west; all appear to occupy the same relative position in the vegetation zonation (Johnson 1959, Greenwood and Brotherson 1978, Brotherson et al. 1984). The communities form a low elevation fringe of vegetation below the xeric border of the coniferous forests. In the southwest Cercocarpus is an important member of chaparral vegetation. The general occurrence of <u>C. montanus</u> on shallow soils has been documented by several investigators (Ramaley 1931, McIntosh 1930, Medin 1960, Brooks 1962). Edaphic characteristics of stands sampled in the present study are listed in Appendix Table A-12.

<u>Quercus macrocarpa</u> Series

The <u>Quercus macrocarpa</u> series is represented along the lower elevations of the northern Black Hills. There it forms woodland communities in which the dominant Quercus are closely spaced, and the stature is that of a small tree. The stands

have physiognomic similarities to those of Quercus gambelii of the central Rocky Mountains. Q. macrocarpa also occurs as a shrub under Pinus ponderosa and as a tree in lowland forests with Fraxinus pennsylvanica, Ulmus americana, Celtis occidentalis, Pinus ponderosa, and Acer negundo. Q. macrocarpa apparently does not occur south of French Creek, and in the Black Hills it is near its westernmost limit of distribution. Previous hybridization between Q. macrocarpa and Q. gambelii in this Region (Maze 1968) has resulted in some taxonomic anomalies. Whether it also resulted in ecologic differentiation within Q. macrocarpa in the Hills is unknown; but this plant is the only one which occurs as a full-statured tree, a small tree and a shrub in this region. Quercus is a dominant only in woodland communities, as indicated previously. Porter (1967) listed Q. macrocarpa var. depressa as "the small scrubby tree of dry uplands," and Q. macrocarpa var. macrocarpa as the tree of "large size in canyons and bottomlands" in eastern Wyoming.

It appears that Quercus is a climax species in all these habitats.

Quercus macrocarpa - Ostrya virginiana habitat type.--- Four of the stands sampled are along the northern fringe of the Black Hills, on the Henry Frawley ranch outside the Forest boundary. The stands are representative of the Quercus/Ostrya plant association, and they have been either ungrazed or grazed moderately (Figure 7). Most stands of the Quercus woodland throughout this region are heavily grazed, and as a result the

Figure 7. Interior of Stand 45, Quercus macrocarpa/Ostrya virginiana habitat type.

undergrowth is much reduced. Grazing animals also aggregate in these stands for the shade. The fifth stand of this habitat type was sampled and recorded mainly for comparison. It is located in Dark Canyon along Rapid Creek and because of the moist conditions, a number of additional species are present (Tables A-1, A-3). This stand is considerably less representative of the plant association.

The stands north of the Forest are at elevations of 1,082 - 1,250 m, on north- and east-facing slopes. Quercus is the sole dominant in this association. Quercus is present in most size classes up to 2-3 dm dbh. In stands 4 and 10 the 3-4 dm dbh size is represented and in stand 20, one specimen in the 4-5 dm dbh size is present. Stand ages range from 66 years to 185 years based on xylem ring counts. Ostrya is a vigorous and abundant shrub reaching about 2-3 m at maturity. Because of its growth form and size classes present Ostrya is recorded with Quercus in appendix Table A-1. A few Fraxinus and Ulmus seedlings present in stands 45 and 4 indicate the presence of a seed source nearby but the plants fail to survive beyond seedling stage. In other stands of this habitat type Pinus ponderosa is present, also as a result of seed sources on higher slopes nearby. Most stands on the Frawley Ranch, however, are fairly distant from the nearest pine stands. Additionally, Quercus stands from xeric knobs of hills downslope to more moist habitats have intrinsic moisture relations which are important in the success or failure of seedling establishment.

As indicated, stand 20 was added for comparison. While it represents the Quercus/Ostrya habitat type it also has characteristics of the more mesic lowland forests in which *Quercus macrocarpa* also occurs. The number of undergrowth species in stand 20 is more than double the number in other stands of this association.

The undergrowth coverage varies considerably among stands of this association. The presence or absence of Carices makes considerable difference in total graminoid cover, yet none of the Carex species carries much indicator value for the habitat type. Except for stand 20, forb coverage is sparse, showing least coverage of any undergrowth in this study.

Undergrowth species of high constancy with constancies of 80 - 100% and their mean coverages are the following:

Species	Constancy	Mean Coverage
Prunus virginiana	80%	6.3%
Berberis repens	80	0.9
Ribes spp.	100	1.1
Symphoricarpos occidentalis	100	2.9
Disporum trachycaulum	80	1.0
Smilacina stellata	100	1.8
Woodsia scopulina	80	0.9
Carex foenea	80	12.1

The average total coverage per stand of these 7 species is 27.0%.

The presence of *Ostrya virginiana* in Quercus stands is a key to this habitat type.

Edaphic characteristics of this habitat type are recorded in Appendix Table A-11.

Quercus macrocarpa/Symphoricarpos occidentalis habitat type.---This h.t. occurs along the northern fringe of the Hills and westward for a limited distance beyond the Hills. The best-developed stands are in the foothills between Sundance, Wyoming, and Whitewood, South Dakota. Most of the stands are heavily grazed and not suitable for sampling in this study. The single stand sampled is west of Whitewood on the east slope of Elkhorn Peak at 1,280 m. Because this stand is rather high on the slope and distant from a water supply, it is utilized only minimally by cattle.

Quercus, the only arborescent species in this h.t., is present in all sizes up to and including 3 - 4 dm dbh (Appendix Table A-1). Stand age based on xylem layer counts is 72 years.

Shrubs dominate the undergrowth and provide 50% coverage. Forbs and graminoids provide 8% and 20% coverage respectively. Heavily grazed stands exhibit very little undergrowth and both shrubs and herbs are decimated. These stands provide easy access to shaded conditions for animals, however.

Pinus ponderosa Series

Pinus ponderosa is the most abundant and most widely distributed tree in the Hills. It occurs from low to high elevation on all substrates and on all aspects. According to Boldt et al. (1983) stands of climax Pinus ponderosa occupy 600,000 ha of the Hills. It is absent from only those areas where trees generally are absent. It is a seral or occasional species in Picea glauca- and Populus tremuloides-dominated vegetation and an occasional tree in more xerophytic woodlands

with Quercus macrocarpa, or in shrub-steppe or steppe vegetation. Claims that it is invading steppe or shrub-steppe are in need of more documentation (Figure 8). The tree may be moving back to an area it once occupied before a major disturbance, in which case the steppe or shrub-steppe is actually a Pinus-dominated habitat type. If this is so, then the species dynamics warrants similar critical consideration here as on sites where it is considered to be climax. Observations during this study indicate this is possibly the case. There is no question that Pinus ponderosa in the Hills is aggressive and reproduction, germination and seedling establishment are prompt and in quantities large enough to maintain the population (Figure 9). Within the Pinus ponderosa series it has little competition from other tree species; following fire or logging it reestablishes and often produces extremely dense stands. Populus tremuloides is the only other tree of consequence in this vegetation series that offers competition with the pine. It produces stands on sites where microclimates match its requirements, but overall Populus tremuloides is a minor tree in the Hills.

Following major disturbance, such as fire, Pinus ponderosa reestablishes promptly within dissemination distance of a seed source and produces a dense stand. Indeed overcrowding is often a serious problem which leads to stagnation of growth. Assuming a normal mortality among the trees, as a result in part of the crowding, growth will be stimulated. Eventually growth differences, along with further mortality of plants, opens the stand and undergrowth species become more obvious. In places no undergrowth occurs under the dense population of pines until some of the trees have died and thinned the stand. Within a century, or less,

Figure 8a. Scattered _Pinus ponderosa_ in the grassland of the southern Black Hills. Some have established within the exclosure shown in this photo.

b. _Andropogon scoparius_ in the foreground near _Pinus ponderosa_. Where the pines form a closed stand, as in the background, Andropogon is much reduced or shaded out entirely.


a


b

Figure 9a. *Pinus ponderosa* is an aggressive species over much of the Black Hills. It is establishing here on a road cut on igneous substrate.

b. On this hillside in the southeastern, dry, part of the Hills pines reestablish more slowly following a fire.

a

b

there are distinct overstory and understory tree populations of at least two ages. Our tree diameter measurements indicate more than two ages may be present in stands we studied.

The Hills have a long history of timber use (Graves 1898). Most of the land is rather easily accessible and roads and trails have threaded over most of the area. Uncontrolled fires, at least during the 1800's and earlier, destroyed much of the Pinus ponderosa forest (Graves 1898). Regeneration of the forest occurred unless fire destroyed it again. With little or no control, repeated fires left much of the Hills with forests "...irregular and broken, and composed in many places of defective and scrubby trees..." (Graves 1898). Since fires have been controlled,the Pinus ponderosa forests have regenerated over most of the Hills. However, the combination of early uncontrolled fires, recent and current intense forest management, and accessibility to grazing animals has influenced the present status of Ponderosa pine-dominated forests in the Hills. Pinus ponderosa may be the climax tree over much of the land area of the Hills, as Boldt et al. (1983) indicated, but most of the stands are not climax. All the intense uses of these forest have kept most of them in seral states and the blended undergrowth vegetation makes habitat type identification more challenging.

Pinus ponderosa extends eastward from the Hills forming small stands along the Pine Ridge Escarpment into central Nebraska and south central South Dakota. It also occurs in

somewhat isolated stands north of the Hills. We encountered and sampled 5 Pinus ponderosa-dominated habitat types in southeastern Montana (Hansen and Hoffman 1986). In the Bighorn Mountains, west of the Hills, we described 5 Pinus ponderosa-dominated habitat types (Hoffman and Alexander 1976).

Pinus ponderosa/Symphoricarpos albus habitat type.--- The Pinus/Symphoricarpos habitat type occurs at elevations from 1400 m to 2000 m, and appears to be the most common Pinus ponderosa-dominated habitat type in the Hills (Figure 10). Stand ages, determined by increment cores taken at breast height, range from 90 to 235 years, and tree basal areas range from 30.8 to 44.5 m^2/ha. There is no indication that basal areas increase within the age range of the stands sampled. Tree populations show a wide range of diameter sizes (age classes?). Some of the stands---39, 54, 24 and 6--- show rather distinct two or three layered overstories. Gaps in the tree diameter size classes are more apparent in the middle sizes, 1-2 dm, and 2-3 dm in particular. These gaps result from sporadic reproduction, seed germination, and establishment. Surface fires can also eliminate an entire population of young trees with bark too thin to resist the heat. This creates an obvious blank in the tree size class distribution.

The undergrowth is variable; those species with constancies of at least 70% and their coverages are the following:

Species	Constancy	Mean Coverage
Amelanchier alnifolia	86%	1.4%
Rosa woodsii	71	0.9
Symphoricarpos albus	100	5.8
Achillea millefolium	86	0.3
Anemone patens	71	0.2
Antennaria plantaginifolia	71	0.4
Campanula rotundifolia	71	0.3

Figure 10. View of Stand 59, Pinus ponderosa/Symphoricarpos albus habitat type. All diameter size classes of pine, up to and including 4 - 5 dm dbh, are present. Total undergrowth coverage in this stand is 60%.

Numbers of undergrowth species per macroplot range from 14 to 28 with a mean of 22 ($\pm$ 2.25). Total undergrowth coverage also is variable ranging from 13% to 60% (Table A-3). The most mature stand (39) of this habitat type is located in Wind Cave National Park on a steep NNE-facing slope. While this is the oldest stand of the h.t. studied, and most free of recent disturbance, both tree basal area and total undergrowth coverage are among the lowest. The climate of the southern part of the Hills is warm and dry, and here the Pinus/Symphoricarpos h.t. is near its xerix limit. In most of the stands examined the undergrowth is patchy. In some, such as stand 39, numerous rock outcrops and many small pebbles are common over the soil surface. Among the stands sampled sand content is highest in the surface soils of stand 39. Edaphic characteristics of the stands are listed in Appendix Table A-11.

The Pinus/Symphoricarpos h.t. has two additional phases in the Hills. They are Pinus/Symphoricarpos Balsamorhiza sagittata phase and Pinus/Symphoricarpos Oryzopsis asperifolia phase. These are distinguished from the typal phase on the basis of considerable amounts of Balsamorhiza and Osmorhiza respectively.

Pinus ponderosa/Symphoricarpos albus habitat type Balsamorhiza sagittata phase.---This phase occurs along the west side of the Hills (Figure 11). It is most conspicuous in the southwest just north of Dead Horse Flats in the Newcastle District. Also, it occurs in the northwestern part along Pole Cabin Gulch, Idol Gulch, and a few other locations in the Spearfish District. This is a minor phase with a restricted distribution along the western edge of the Hills. A recent flora of South Dakota Van Bruggen 1976)

Figure 11. A stand of Pinus ponderosa/Symphoricarpos albus habitat type Balsamorhiza sagittata phase. The phase is best developed in the southwestern Hills.

states that _Balsamorhiza sagittata_ is "rare in the woods of Lawrence and Pennington counties." In stand 61 its coverage is 12% and its frequency is 60%. Overall the plant has a limited distribution, but where it occurs it may be abundant. Stand 61 is 290 years old. There are no signs of recent grazing but the stand has been thinned sometime in the past. Stand 13 is only 100 years old. These two stands have been combined in the same phase on the basis of the presence of Balsamorhiza primarily. Stand 61 has more graminoids with considerably more coverage than Stand 13 which exemplifies the variation encountered in this floristically rich h.t. (Appendix Table A-4). See discussion below. Edaphic characteristics of the sampled stands are listed in Appendix Table A-11.

Pinus ponderosa/Symphoricarpos albus habitat type _Oryzopsis asperifolia_ phase.---This phase was sampled in only three stands all of which are on igneous substrate of the "central core" region. Tree basal areas are similar in all three stands, 33.8 - 37.1 m^2/ha, though ages of the stands differ by more than 100 years. It is not unusual for a lack of correlation between basal area and age of _Pinus ponderosa_ forests. The undergrowth of this phase is characterized by the conspicuous _Oryzopsis asperifolia_ and the presence of _Symphoricarpos albus_ and its associates. _Arctostaphylos uva-ursi_ is prominent in two of the three stands sampled (Appendix Table A-4).

The Pinus/Symphoricarpos h.t. in the Hills is widespread, and species composition of the vegetation is quite variable. It is the richest in species among all the h.ts. of this study. Including the two phases, it has 20 shrub, 67 herbaceous, and 27 graminoid species. Elsewhere the *Pinus ponderosa/Symphoricarpos albus* association is also rich in species. Daubenmire and Daubenmire (1968) recorded 124 species in stands of their Pinus/Symphoricarpos h.t., the high among *P. ponderosa*-dominated associations in eastern Washington and northern Idaho. Pfister et al. (1977) recorded 120 species in stands of their Pinus/Symphoricarpos h.t. in Montana. This was second high behind Pinus/*Festuca idahoensis* among their *P. ponderosa*-dominated h.ts. The h.t. occurs in moderate environments over a broad area of the Hills. Because of the moderate conditions and the fact that the forests are easily accessible, the land area of this h.t. is heavily used. Climax stands are very difficult to locate. Though Thilenius (1972) did not consider climax vegetation or delimit habitat types, it is relevant that he included *Symphoricarpos albus* in naming 7 of the 13 "habitat units" he described in the Hills. The composition of these 7 "habitat units" varied considerably, but *Symphoricarpos albus* was obviously important in all seven. A *Pinus ponderosa/Symphoricarpos albus* h.t. occurs on benchlands and north-facing slopes in east central and southeastern Montana (Pfister et al. 1977).

Pinus ponderosa/Juniperus scopulorum h.t.---Pinus/J. scopulorum occurs in the dry southern part of the Hills, mainly on steep rocky slopes. The stands vary from relatively closed to open. Because of the limited distribution of this h.t. and its occurrence mainly outside the forest, I sampled only one stand, number 58, intensively and evaluated five other stands on a reconnaissance basis. The stand sampled (Figure 12) is on BLM land south of the National Forest boundary. In the Elk Mountains the Pinus/J. scopulorum h.t. occurs on steep slopes with Juniperus much less common along the crest and gentle slopes of the range where the soil is somewhat deeper.

Based on the number of xylem rings at breast height of the two largest trees, stand 58 is approximately 190 years old. I measured stem diameters of the Juniperus for basal area calculation (App. Table A-1) and where its lower branches were present in microplots I estimated its canopy coverage near the ground surface. Juniperus forms a poorly defined shrub layer in the structure of this vegetation. Mostly the plants are rather unevenly dispersed throughout. Because numerous of the stands are quite open, the vegetation structure is less perceptible; and owing to the high light intensity at the ground level the undergrowth shares a number of species with the adjacent steppe. Anemone patens, Agropyron smithii, Andropogon scoparius, Bouteloua curtipendula, Carex filifolia, Koeleria pyramidata, and Oryzopsis hymenoides are representative examples.

The Pinus ponderosa/Juniperus scopulorum h.t. was not described for the Bighorn National Forest (Hoffman and Alexander

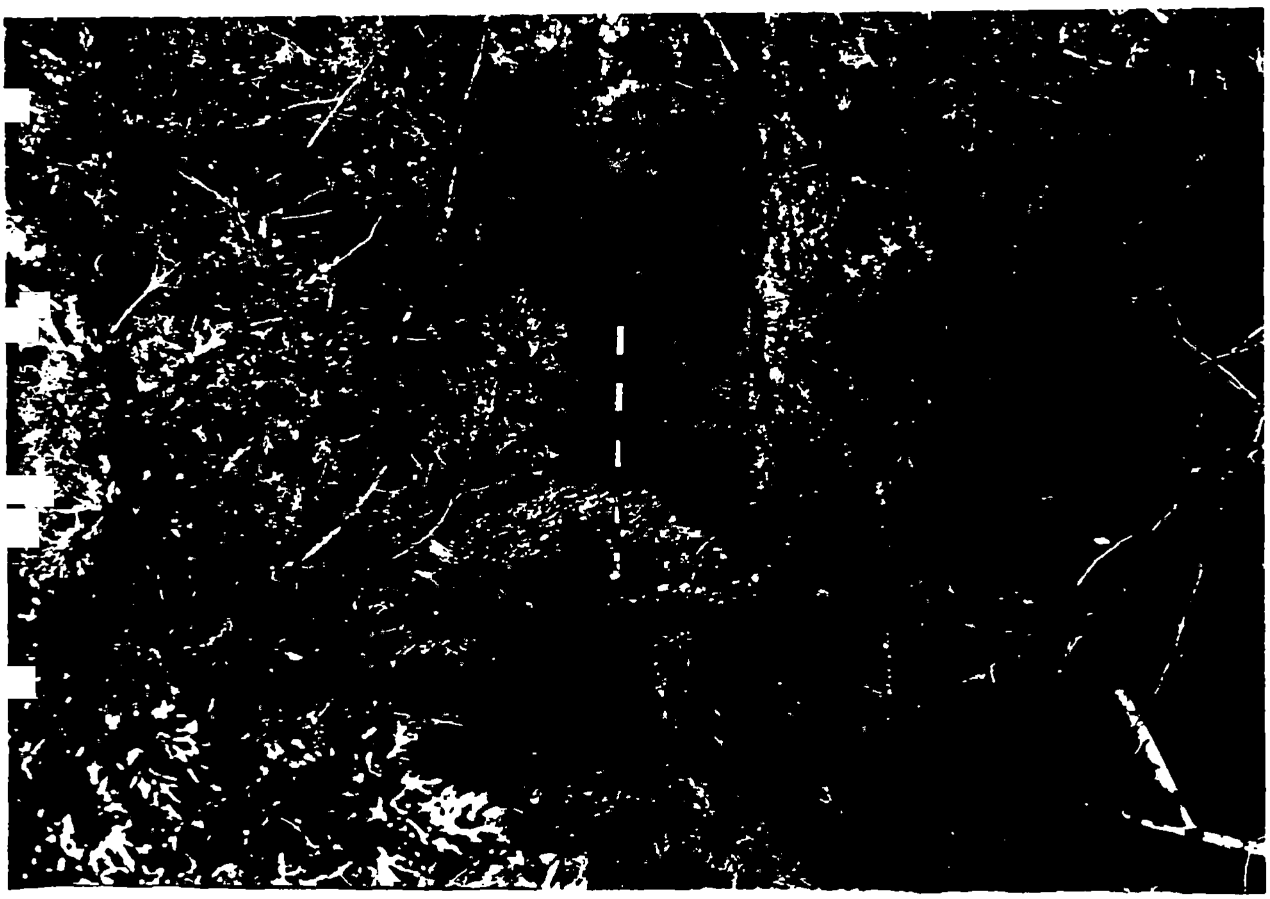


Figure 12. Stand 58, Pinus ponderosa/Juniperus scopulorum habitat type. Both Pinus and Juniperus are abundant. Undergrowth vegetation is relatively sparse.

1976), though J. scopulorum is present in the Pseudotsuga menziesii/Physocarpus monogynus h.t. on the west (xeric) slopes. J. scopulorum also extends downslope beyond the Forest boundary of the Bighorns, into the adjacent shrub-steppe. Wirsing and Alexander (1975) did not describe a P. ponderosa/J. scopulorum h.t. for the Medicine Bow National Forest in southern Wyoming. Hoffman and Alexander (1980) also did not describe a P. ponderosa/J. scopulorum h.t. in the Routt National Forest of northwestern Colorado. Pfister et al. (1977) did not describe a P. ponderosa/J. scopulorum h.t. anywhere in Montana. Edaphic characteristics of Stand 58 are given in Table A-11.

Pinus ponderosa/Carex heliophila habitat type.---The Pinus/Carex h.t. is scattered mainly in peripheral locations of the Hills. The best stand sampled, number 63, is in the Elk Mountains (Figure 13). There the trees are relatively widely spaced and considerable sunlight reaches the ground surface. Pinus is present in this h.t. in a range of size classes up to 5-6 dm dbh (Appendix Table A-1). Gaps in the range of size classes present is consistent with most Pinus ponderosa forests of the Hills. Some Quercus macrocarpa also occur in stand 49. Tree basal areas range from 37.8 to 48.5 m^2/ha.

Abundant Carex heliophila characterizes the undergrowth (Figure 13). Its coverage may be nearly 50% in some stands (Appendix Table 6). C. heliophila and Poa pratensis are the only species with 100% constancy. Species with constancies of at least 67% and their coverages are the following:

Figure 13. Pinus ponderosa/Carex heliophila habitat type in the Elk Mountains, southwestern Black Hills. The undergrowth is characterized by a nearly complete sward of Carex helioph with few other species present. Abundant pine seedlings and saplings are present in the background.

Species	Constancy	Mean Coverage
Carex heliophila	100%	37%
Poa pratensis	100	3.4
Antennaria plantaginifolia	67	0.3
Artemisia ludoviciana	67	0.5
Campanula rotundifolia	67	0.1
Danthonia spicata	67	4.3
Stipa occidentalis	67	---

Shrubs are not very important in the vegetation. The total number of species in stands sampled is 43, and total undergrowth coverage ranges from 47% to 86%. Graminoids constitute 67% to 98% of the total undergrowth coverage.

Hansen and Hoffman (1986) described a Pinus ponderosa/Carex heliophila h.t. in the Custer National Forest of northwestern South Dakota and southeastern Montana. We encountered 34 species in our samples; both C. heliophila and Agropyron spicatum are important undergrowth species. Graminoids make up 98% to 100% of the undergrowth coverage.

This h.t. may be restricted to an eastern fringe, for it has not been reported from any other areas of the Rocky Mountains so far studied. In the xeric P. ponderosa/Agropyron spicatum and P. ponderosa/Festuca idahoensis h.ts. in the Bighorn Mountains (Hoffman and Alexander 1976) and in southeastern Montana (Pfister et al. 1977) Carex heliophila does not occur.

Edaphic characteristics of the Pinus/Carex h.t. are recorded in Appendix Table A-11.

Pinus ponderosa/Physocarpus monogynus habitat type.--- The Pinus/Physocarpus h.t. occurs in the southwestern and southern Hills. Good stands occur on N-NNW facing slopes at Jewel Cave National Monument, and in Boles and Redbird Canyons.

It appears to be more mesic than the Pinus/Symphoricarpos h.t. which is present higher on the same steep slopes at Jewel Cave National Monument. Tree basal areas range from 31.9 to 45.5 m^2/ha in sampled stands. The largest trees are 3-4 dm dbh. The tree population of stand 57 shows the effects of relatively recent fire. Young trees with thin bark, killed easily by fire, are absent from this stand. Additionally, litter and duff, which can retard seed germination and establishment, but removed by fire to expose a bare mineral soil, allows vigorous seedling eastablishment as shown. Stands 64 and 65 have been unburned for considerably longer times. The times of burning are not established in this study. _Physocarpus monogynus_ dominates an undergrowth (Figure 14) of shrubs and forbs primarily. High constancy species and their mean coverages are the following:

Species	Constancy	Mean Coverage
Physocarpus monogynus	100%	42%
Prunus virginiana	100	3.4
Rosa acicularis	100	1.8
Symphoricarpos albus	100	8.9
Mosses + Lichens	100	29
Agropyron caninum	100	1.1

Nine species were present in two of the three stands sampled. As shown in Appendix Table A-6, coverage of graminoids in these stands is 0 - 3%.

Hoffman and Alexander (1976) described a _Pinus ponderosa/ Physocarpus monogynus_ h.t. in the Bighorn Mountains, Wyoming, where few floristic similarities are found with the same h.t. in the Black Hills. In both areas, however, the h.t. is on

Figure 14. Pinus ponderosa/Physocarpus monogynus habitat type. Physocarpus dominates a relatively dense undergrowth. Photo taken in Boles Canyon.

northerly slopes and shrubs dominate the undergrowth. Where shrubs have high coverage, herbaceous species are much less abundant. Daubenmire and Daubenmire (1968) described a _P_. _ponderosa_/_Physocarpus_ _malvaceus_ h.t. in the northern Rockies, also confined to northerly slopes. The dominant shrubs there are tall and very dense and there is little floristic similarity to the Pinus/Physocarpus h.t. in the Black Hills. A similar h.t. does not occur in Montana (Pfister et al. 1977) and Physocarpus is not in any _Pinus_ _ponderosa_ dominated vegetation of southeastern Montana and adjacent South Dakota (Hansen and Hoffman 1986).

In the Hills the soils under Pinus/Physocarpus vegetation may be somewhat more fertile (Appendix Table A-11) and, based on topographic position, more moist than those under Pinus/ Symphoricarpos vegetation.

Where Pinus/Physocarpus occurs, in the southwestern Hills, succession after fire appears to include a stage of _Cercocarpus montanus_ which is eventually shaded out under Pinus. But some stands in this area with Pinus and Cercocarpus are not categorized as h.ts. The population structures of Pinus and Cercocarpus may be unstable, but at present there is little evidence to suggest whether Pinus will form a closed canopy and the Cercocarpus will be removed from the undergrowth. Some stands are simply ecotonal between Pinus-dominated forests and Cercocarpus-dominated shrub-steppe.

Pinus ponderosa/Quercus macrocarpa habitat type.--- The Pinus/Quercus h.t. occurs in the northern part of the forest. It is most conspicuous in the Bear Lodge Mountains. The sampled stands are all on calcareous substrates, though the h.t. occurs on some apparently igneous substrates of the northeastern Hills. Pinus is the sole dominant of the vegetation and in three of the sampled stands is present up to and including 5 - 6 dm dbh (Appendix Table A-1).

The undergrowth is dominated by *Quercus macrocarpa* which I consider the key to recognizing the h.t. (Figure 15). Quercus is abundant and large in stature over much of the Bear Lodge Mountains where both grazing and logging have altered the pine forests. Yet, in the shade of pines in old stands, Quercus remains a conspicuous undergrowth plant and the h.t. is readily recognized. The coverage of Quercus is less than 30% in any stand sampled and is only 4.0% in stand 68 where *Prunus virginiana* has a coverage of 45%. *Prunus virginiana* and *Berberis repens* are common shrubs and in stand 68 they also have relatively high coverage. These two species are widely distributed and they occur in every habitat type in the Hills dominated by *Pinus ponderosa* and *Populus tremuloides* except for the xeric *Pinus/J. scopulorum* h.t. North of the Hills, in the Custer National Forest, we designated a *Pinus ponderosa/Prunus virginiana* h.t. in which Prunus and Berberis are both abundant. However, these plants are absent or rare in the other Pinus-dominated h.ts. of that region (Hansen and Hoffman 1986).

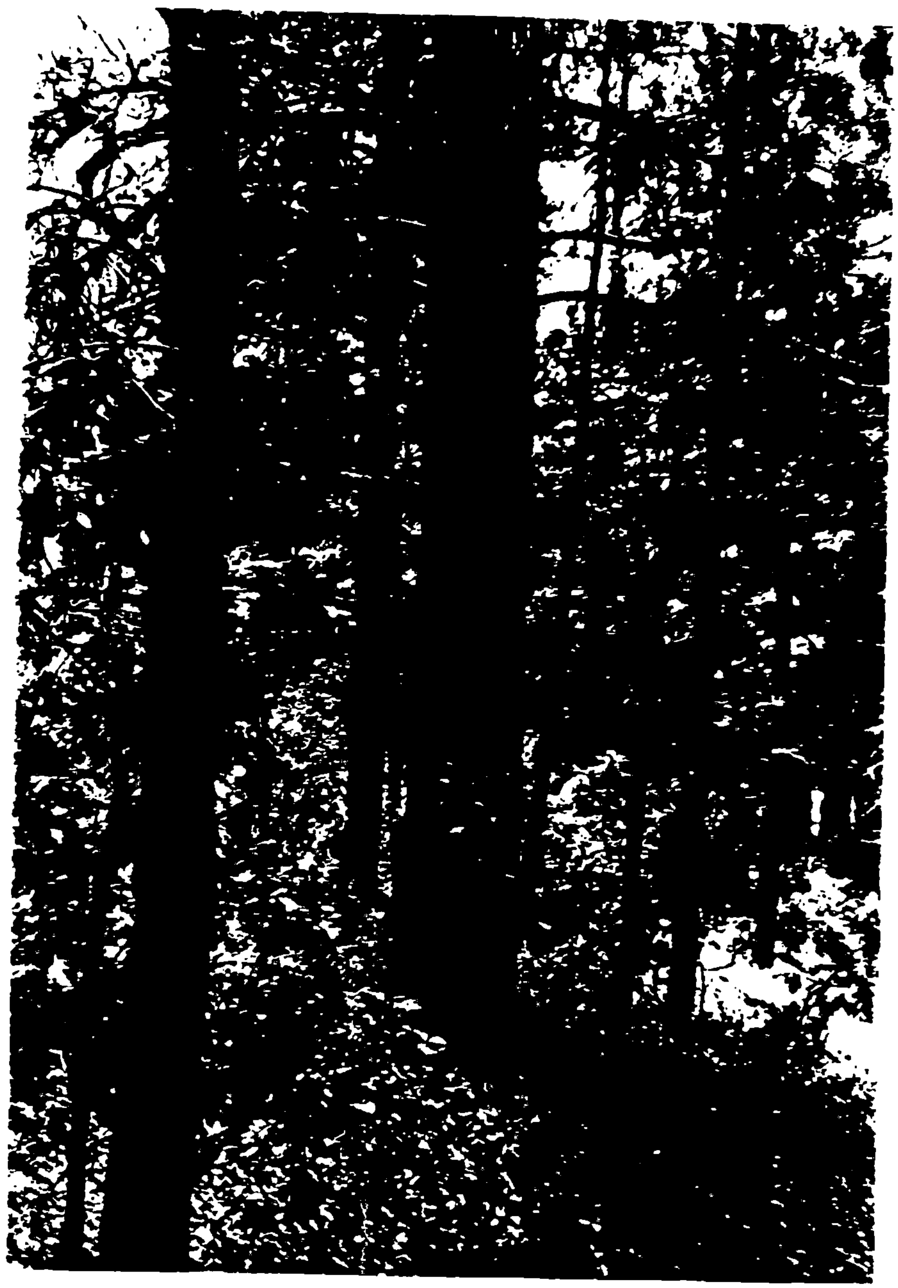


Figure 15. _Pinus ponderosa/Quercus macrocarpa_ habitat type. Though it becomes a tall shrub, Quercus does not reach the canopy of this forest. Pines are present in several size classes. Photo taken in the Bear Lodge Mountains.

Undergrowth species with constancies of at least 75% and their mean coverages are the following:

Species	Constancy	Mean Coverage
Amelanchier alnifolia	75%	3.5%
Berberis repens	100	7.5
Prunus virginiana	75	13
Quercus macrocarpa	100	18
Rosa acicularis	100	0.6
Spiraea betulifolia	100	8.6
Antennaria plantaginifolia	75	--
Apocynum androsaemifolium	75	0.4
Aster ciliolatus	75	0.6
Campanula rotundifolia	75	0.1
Galium boreale	75	1.0
Lupinus argenteus	75	0.9
Monarda fistulosa	75	0.1
Smilacina stellata	75	1.0
Vicia americana	75	0.2
Agropyron caninum	75	0.9
Carex foenea	100	2.8
Danthonia spicata	75	0.7
Oryzopsis asperifolia	75	3.4

The above list shows nearly one-third of the total species of this vegetation have high constancies. Of the five with 100% constancy, four are shrubs.

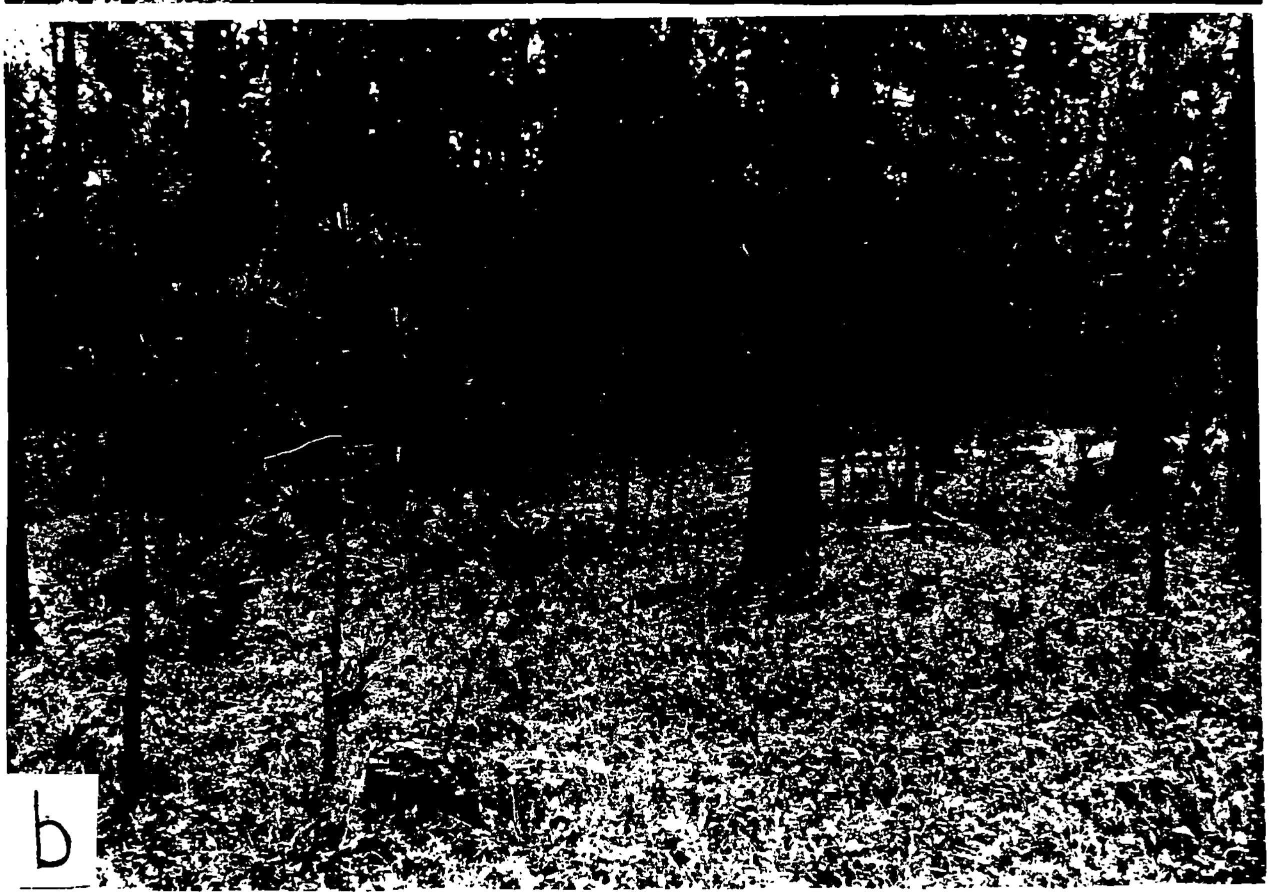
Edaphic characteristics of the stands studied are listed in Appendix Table A-11.

Pinus ponderosa/Arctostaphylos uva-ursi habitat type.--- The Pinus/Arctostaphylos h.t. is widespread over the igneous central core region; it also occurs on some calcareous substrates. Its elevational range is 1548 m to 2042 m among the stands sampled. The most mature stands of the vegetation occur in Starling Canyon within the boundary of Mt. Rushmore National Monument. Here the largest pines are 5 - 6 dm dbh with ages exceeding 250 years. Those cored for age are also sound to their piths. Blackened snags in the Canyon indicate fire occurred some time in the past. Tree population data of stands 62 and 66, both in Starling Canyon (Figure 16), reveal the episodic nature of pine reproduction and establishment (Appendix Table A-1). These two stands are as close to climax as any in the Hills, and their tree basal areas are 44.1 and 25.2 m^2/ha respectively. Of the 10 stands of Pinus/Arctostaphylos sampled three have basal areas greater than 44.1 m^2/ha but none is lower than 25.2 m^2/ha (Appendix Table A-1). In three stands *Populus tremuloides* and in one stand *Quercus macrocarpa* are present in the seedling class.

The undergrowth has 82 species, second only to the Pinus/Symphoricarpos association. Total coverage ranges from 23% in stand 16 to 118% in stand 62. Arctostaphylos generally produces the greatest coverage of the undergrowth species. Both stands 16 and 17 are located on the Nemo Experimental Forest (Figure 17a, b). Both have histories of management; their tree populations show all size classes up to the maximum size present (Appendix Table A-1). The undergrowth

Figure 16. Stand 66, Pinus ponderosa/Arctostaphylos uva-ursi habitat type. Large pines are widely spaced, but many young trees are visible in the background. Arctostaphylos forms an almost complete carpet over the ground surface.


a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in stand 16 is very patchy, Arctostaphylos has a coverage of only 10%, and total undergrowth coverage is only 23%. In stand 17 Arctostaphylos has a coverage of 25% and the total undergrowth coverage is 33%. Stand 16 may represent the xeric limit that supports this vegetation. Stands 62 and 66 have undergrowth coverages of 117% and 118% respectively, the highest of any Pinus-dominated vegetation, except for stand 65, Pinus/Physocarpus, where the undergrowth coverage is 135%, 71% of which is of mosses and lichens. Arctostaphylos shows 76% and 85% coverage in stands 62 and 65 respectively and 100% frequency in each. Arctostaphylos generally has high frequency if not high coverage in this h.t. Among the stands sampled species with constancies of at least 70% and their mean coverages are the following:

Species	Constancy	Mean Coverage
Arctostaphylos uva-ursi	100%	33%
Rosa acicularis	70	0.4
Symphoricarpos albus	100	3.4
Achillea millefolium	100	0.6
Fragaria virginiana	80	0.5
Lathyrus ochroleucus	80	2.2
Oryzopsis asperifolia	100	4.1

Thilenius (1972) included Arctostaphylos in naming two of his habitat units in the Black Hills. DeVelice et al. (1984) described a Pinus ponderosa/Arctostaphylos uva-ursi h.t. in northern New Mexico. There is no similar h.t. in the Bighorn Mountains in Wyoming (Hoffman and Alexander 1976) or the Custer National Forest in southeastern Montana and adjacent South Dakota (Hansen and Hoffman 1986). A similar h.t. apparently

does not occur in Montana (Pfister et al. 1977). Edaphic characteristics are listed in Appendix Table A-11.

Pinus ponderosa/Juniperus communis habitat type.--- The Pinus/*J. communis* h.t. is widely distributed on the limestone plateau over the western half of the Hills. The elevational range of stands sampled is 1394 - 1989 m which overlaps that of all other Pinus-dominated h.ts. except for Pinus/*J. scopulorum* of lower elevation. All stands sampled of the Pinus/*J. communis* h.t. are SSW to NNE facing on relatively gentle slopes. The h.t. can also occur on igneous substrates of the central core region in the Hills.

Pinus is the sole dominant and occasionally *Populus tremuloides* is present. In stand 8 *Betula papyrifera* and a few *Picea glauca* are also present. Stand 8 possibly represents a Picea-dominated h.t. but it lacks some critical indicator species and Picea seedlings are not there. More about succession in these forests is presented below. Tree basal areas in stands sampled are 29.4 m^2/ha to 52.3 m^2/ha.

The undergrowth of this association is characterized by the presence, and ordinarily the dominance, of *Juniperus communis* (Figure 18). *Berberis repens* is also a constant member of this association. In all, 68 species occur in the undergrowth. Total undergrowth coverage ranges from 33% to 76%. The combined coverage of *Juniperus communis* and *Berberis repens* ranges from 11% to 44%. Species with constancies of at least 70% and their mean coverages are the following:

Figure 18. View of Stand 1, Pinus ponderosa/Juniperus communis habitat type. J. communis has 28% coverage and 52% frequency in this stand. This stand is marked for cutting. Pinus is represented in every size class up to and including 4 - 5 dm dbh.

Species	Constancy	Mean Coverage
Arctostaphylos uva-ursi	71%	4.7%
Berberis repens	100	4.1
Juniperus communis	100	25
Rosa acicularis	86	0.4
Spiraea betulifolia	71	2.4
Symphoricarpos albus	86	8.4
Achillea millefolium	86	0.3
Fragaria virginiana	86	0.8
Lupinus argenteus	86	0.2

This list is similar to that of the high constancy species in the Pinus/Arctostaphylos association, but it is distinguished primarily by the presence of Juniperus communis, Berberis repens, and Lupinus argenteus, and the absence of Lathyrus ochroleucus, and Oryzopsis asperifolia. The undergrowth structure of this association is characterized by Juniperus communis, up to a meter or more tall, and a layer of smaller shrubs and herbs in the spaces among the Juniperus.

Some stands of Pinus/J. communis are seral to Picea glauca-dominated vegetation, indicator species of which will be present. In some locations Picea glauca has developed a population which appears to be succeeding Pinus ponderosa (Figure 19).

There is some similarity among the high constancy species lists of most Pinus-dominated h.ts. in the Black Hills. Pinus/J. scopulorum and Pinus/Carex heliophylla stand out because of their xerophytic nature and they share few species with the

Figure 19. A stand of Pinus ponderosa in which Picea glauca has become well established. Note the Juniperus communis in the undergrowth.

other five Pinus-dominated h.ts. Among these five h.ts. no species has high constancy in all. _Symphoricarpos_ _albus_ and _Rosa_ _acicularis_ have high constancy in four and _Achillea_ _millefolium_ has high constancy in three of the five h.ts. Using Jaccard's coefficient of similarity for the high constancy species only similarities for each pair of h.ts. are given below. Pinus/_J_. _scopulorum_ is not included.

	Pinus/ Carex	Pinus/ Symphoricarpos	Pinus/ Physocarpus	Pinus/ Quercus	Pinus/ Arctostaphylos	Pinus/ _J_. _communis_
Pinus/Carex	100%	29%	0%	15%	0%	0%
Pinus/Symphoricarpos		100%	15%	23%	29%	25%
Pinus/Physocarpus			100%	24%	31%	27%
Pinus/Quercus				100%	15%	29%
Pinus/Arctostaphylos					100%	63%
Pinus/_J_. _communis_						100%

The relatively low similarity values indicate considerable separation of high constancy species among the habitat types. Comparing total species lists, the similarity values are usually higher; between the Pinus/Symphoricarpos and Pinus/Physocarpus h.ts. it is 48% and only 15% for high constancy species.

High constancy species are critical indicators of h.ts. and of greater value in comparing similarities than total species lists. A refinement of the comparisons is possible by including coverages of the high constancy species in the similarity index calculation.

Populus tremuloides Series

Populus tremuloides is not an important timber species in the Black Hills covering only about 5% of the area (Severson and Thilenius 1976). Forests dominated by *Populus tremuloides* provide wildlife and domestic animal habitat and esthetic characteristics all more valuable than the limited extent of the forests might suggest.

Hayward (1928) and McIntosh (1930) reported *Populus tremuloides* as a seral species only in the Black Hills. Severson and Thilenius (1976) classified but did not report on the successional status of *P. tremuloides* stands in the Black Hills. Though it is seral over much of its range, *P. tremuloides* is also climax in various habitats. It is common for *P. tremuloides* to separate conifer forests on coarse-textured substrates of mountain slopes from the fine-textured substrates of adjacent parks (Figure 20). Most stands of this tree are initiated by destruction of forests dominated by conifers (Hoffman and Alexander 1980). Mueggler (1976) suggested the only reliable evidence of succession from *P. tremuloides*-dominated forests to conifer-dominated forests is a multilayered understory of climax

Figure 20. The lower edge of the conifer forest is fringed with Populus tremuloides. Extending onto the area adjacent the stream is a stand of Salix spp. many of which are being eliminated in favor of herbaceous vegetation for domestic animals.

coniferous species. I agree with this; an occasional conifer in a Populus stand is not evidence of succession. Where he examined _P. tremuloides_ stands in Utah, Mueggler (1976) suggested that even in the absence of fire as long as 1000 years might be required for the succession of _P. tremuloides_ forests to climax coniferous forests. If this time span is close to accurate, and I have no evidence to prove otherwise, then self-reproducing forests of _P. tremuloides_ showing no evidence of succession toward conifer-dominated forests, should be considered climax and the sites treated as habitat types on which _P. tremuloides_ is the dominant species (Hoffman and Alexander 1980). In the Black Hills seral communities of _P. tremuloides_ most commonly occur on _Picea glauca_ sites and succession is evident in a number of these stands (Figure 21). Control of fires has changed the distribution of _P. tremuloides_ in the Black Hills. In _Pinus ponderosa_ forests where management includes burning piles of pine stems and branches, Populus sprouts are not uncommon in the _P. ponderosa_/_Arctostaphylos uva-ursi_ and _P. ponderosa_/_Juniperus communis_ h.ts. (Appendix Table A-1). These small plants are not evidence of succession, however. Some stands of _Populus tremuloides_, not sampled in this study, are seral to one or both of these Pinus-dominated h.ts. In a recently built exclosure in Custer State Park _P. tremuloides_ developed a dense stand of saplings within two years (Figure 22). Releasing the pressure of animal activity is evident. It can lead to such conclusions as "trees are encroaching onto grasslands" when in fact the "grasslands" may be occupying forest habitat types.

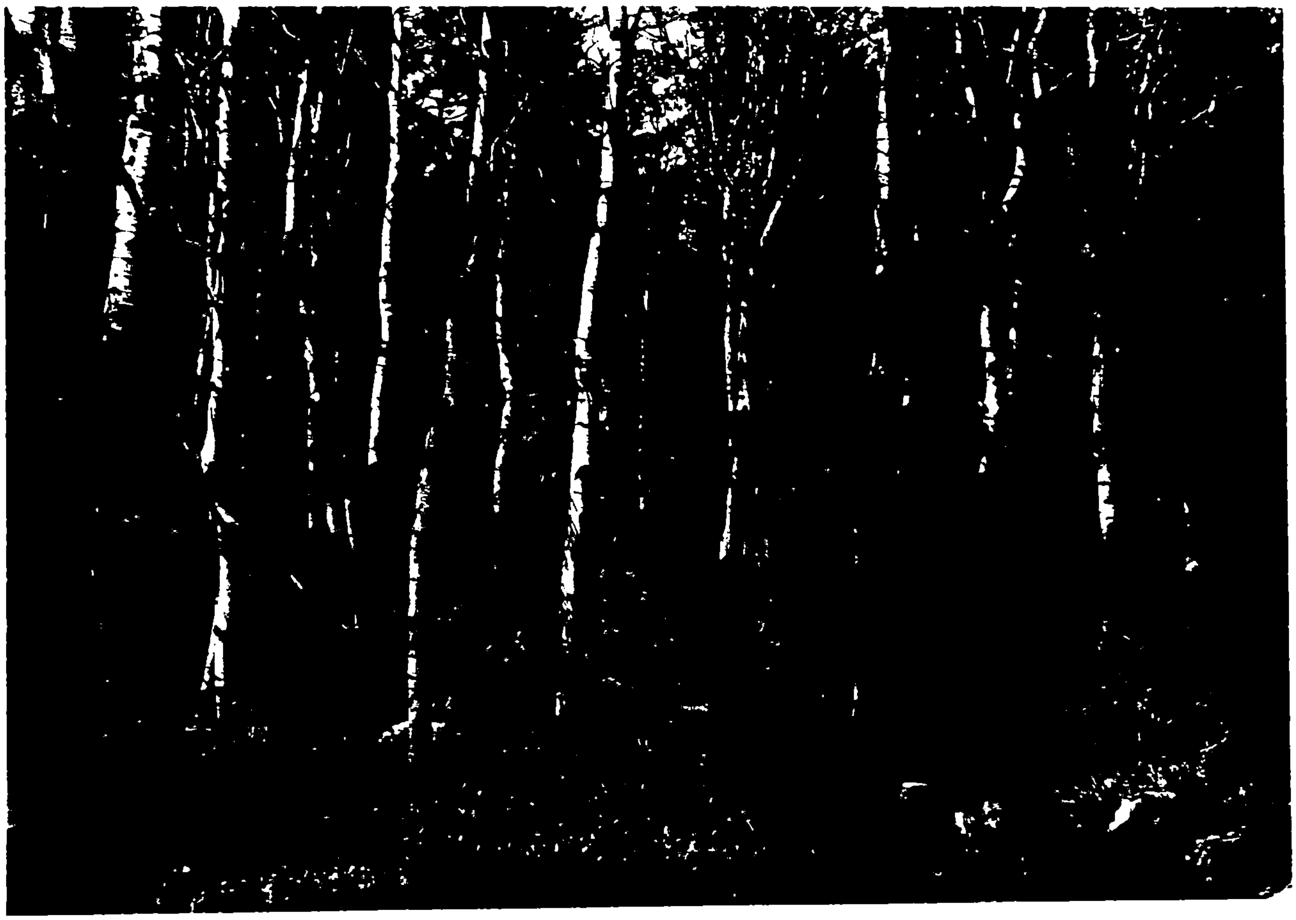

Figure 21. A community of Populus tremuloides occupying a Picea glauca-dominated habitat type. Picea has become well-established on the site.

Figure 22. A two-year old exclosure in Custer State Park. The absence of animal activity has resulted in Populus tremuloides developing a dense stand already 1-2 m tall.

In most Populus stands Betula papyrifera is a subdominant species; its stature is less than that of Populus and in numerous places its ecologic role is that of an understory shrub. Hayward (1928) and McIntosh (1930) both described Populus tremuloides-Betula papyrifera forests on recently burned areas of the Hills. From their lists of undergrowth species, it is apparent their Populus-Betula forests occupied Picea glauca-dominated h.ts. and perhaps the Pinus ponderosa/ Juniperus communis h.t.

Populus tremuloides/Corylus cornuta habitat type.---This is the only P. tremuloides-dominated h.t. in the Hills. Two other phases are described below. Populus is dominant though other tree species commonly occur. Betula papyrifera is a subdominant tree or tall shrub. In stand 31 it has a few large specimens (Appendix Table A-1). Quercus macrocarpa is well-represented in stands 67 and 2 in the central Hills. Pinus ponderosa and Picea glauca rarely occur in this h.t. Based on increment cores taken at breast height stand 55 is 115 years old (Figure 23) though most Populus tremuloides stands in the Hills are younger than 100 years. In this study tree basal areas range from 27.6 m^2/ha to 33.7 m^2/ha.

With 91 undergrowth species the Populus/Corylus h.t. is second only to Pinus/Symphoricarpos in species richness in the Black Hills. In some stands, 67 as an example, Corylus cornuta is so dense that human movement through them is difficult. Under the Corylus is a rich layer of mainly herbaceous species. Aralia nudicaulis is conspicuous at 3-5 dm. Undergrowth species with

Figure 23. A view of Stand 55, Populus tremuloides/Corylus cornuta habitat type. The large tree next to the meter stick is 4-5 dm dbh. In this stand both Betula papyrifera and Ostrya virginiana are present in the shrub layer.

constancies of at least 83% and their coverages are the following:

Species	Constancy	Mean Coverage
Amelanchier alnifolia	100%	3.5%
*Corylus cornuta**	83	50.2
*Lonicera dioica**	83	1.8
Prunus virginiana	83	1.0
*Pyrola asarifolia**	83	4.1
Rosa acicularis	83	1.0
*Rubus idaeus**	83	0.6
Spiraea betulifolia	83	2.6
Symphoricarpos albus	100	3.1
*Actaea rubra**	83	4.0
*Aralia nudicaulis**	100	8.0
Aster ciliolatus	83	2.1
Fragaria virginiana	83	1.7
Galium triflorum	100	2.1
Lathyrus ochroleucus	83	1.0
*Maianthemum canadense**	100	2.5
Osmorhiza chilensis	83	4.0
*Sanicula marilandica**	83	1.0
Smilacina stellata	100	1.1
*Thalictrum dasycarpum**	100	2.5
*Viola canadensis**	100	7.5
Oryzopsis asperifolia	83	4.9

As a group those followed by an asterisk are valid indicators of the undergrowth unions of this vegetation. The lengthy list of high constancy species indicates further the richness of the undergrowth. In stand 30, 44 undergrowth species are present in 50 - 2x5 dm microplots; the average number of species per microplot is 8.8 (± 2.3). Undergrowth coverage ranges from 64% to 215%. Mean coverage for the 5 stands in which Corylus dominates the undergrowth is 161% (± 37%). Except for the two other phases of the same h.t., this is easily the greatest undergrowth coverage among the forest h.ts. in the Hills. Forbs and shrubs provide the greatest coverage (Appendix Table A-7). A *Populus tremuloides*/

Corylus cornuta h.t. has not been described elsewhere in the Rocky Mountains. North of the Hills in the Custer National Forest we described a Populus tremuloides/Berberis repens h.t. which shares with Populus/Corylus a number of species (Hansen and Hoffman 1986).

Edaphic characteristics of the Populus/Corylus h.t. are given in Appendix Table A-11.

Populus tremuloides/Corylus cornuta habitat type Pteridium aquilinum phase.---This phase is represented by two stands located in the Bear Lodge Mountains (Figure 24). Populus is dominant, and some seedlings of Quercus macrocarpa and Pinus ponderosa are present in stand 26. Tree basal areas are 41.7 and 52.3 m^2/ha for stands 25 and 26 respectively. Betula papyrifera is absent from both stands. The undergrowth shares many species with the Populus/Corylus h.t. (Appendix Table A-9). Species that are present in both stands 25 and 26 but have constancies less than 83% in Populus/Corylus stands are the following:

Species	Average Coverage
Pteridium aquilinum	28%
Melica subulata	8.8
Anaphalis margaritacea	1.0
Pyrola elliptica	0.6
Habenaria viridis	+
Heuchera richardsonii	+
Ranunculus abortivus	+
Carex sprengelii	+

Of the species listed, only Pteridium, Melica, Anaphalis and Pyrola have average coverages greater than 0.5%. Additionally, only Pteridium and Melica have frequencies greater than 50%.

Figure 24. A view of Stand 26, Populus tremuloides/Corylus cornuta habitat type Pteridium aquilinum phase. Pteridium has a coverage of 33% in this stand. Amelanchier alnifolia and Corylus cornuta make up a large but not dense shrub layer.

This is significant because a useful indicator species must have both coverage and frequency great enough to be observed relatively easily. Some species have very high fidelity in particular habitat types and are potentially valuable as indicator species for those h.ts. If those same species have very low frequencies they are practically worthless as indicators.

Though Pteridium aquilinum establishes readily following fire, it may remain on an area for a long time. In Finland, Oinonen (1967) found some P. aquilinum clones there to be 1,200 years old. In our region, stands of Populus/Pteridium that are nearly 100 years old and the Pteridium is still vigorous and dominant in the undergrowth are considered habitat type status.

We reported Populus/Pteridium habitat types from the Routt and White River National Forests in Colorado (Hoffman and Alexander 1980, 1983). One also occurs in southwestern Colorado in the Uncompahgre National Forest (Hoffman, unpublished data, 1986). However, no similar habitat type occurs in the Bighorn Mountains or the Custer National Forest west and north of the Hills respectively.

The soils are somewhat distinct from those of the Populus/Corylus h.t. and the Populus/Corylus Aralia phase. Under Populus/Corylus Pteridium the upper dm of the soil contains more exchangeable Ca and Mg, a higher cation exchange capacity (C.E.C.), and more organic matter (Appendix Table A-11).

Populus tremuloides/Corylus cornuta habitat type Aralia nudicaulis Phase.--- This phase is represented by only one stand. It is distinguished primarily on the basis of abundant Aralia that dominates the undergrowth (Figure 25). It also has

Figure 25. A view of Stand 43, Populus tremuloides/Corylus cornuta habitat type Aralia nudicaulis phase. Aralia has 47% coverage in this stand. Betula papyrifera is an abundant subdominant in this stand.

conspicuous amounts of Rubus idaeus, Aster ciliolatus, Halenia deflexa, Sanicula marilandica, and Toxicodendron rydbergii. Abundant grasses are Poa pratensis and Phleum pratense both of which are introduced (Appendix Table A-9). This stand may be distinct as a result of animal grazing. It is a one-of-a kind stand; if they were present more stands would clarify the status. At present it is considered a phase of the Populus/Corylus h.t.

There is evidence of fire some time ago, and a few Picea glauca occur nearby. A small stand of Populus/Pteridium also occurs nearby. The tree population of this stand includes Betula papyrifera as a subdominant and a number of Quercus macrocarpa seedlings.

Edaphic characteristics of this stand are given in Appendix Table A-11.

Picea glauca Series

The Picea glauca series occurs at high elevations and in cool sites of canyon bottoms. Temperature is more important as a controlling factor than substrate as the spruce forests occur on both igneous and limestone substrates in the Hills. The Black Hills is one of the locations in the Rockies, south of the U.S.-Canadian border, where apparently pure populations of this species occurs. To the west, in the Bighorn Mountains, spruce populations show evidence that introgression occurred between P. engelmannii and hybrids of P. engelmannii X P. glauca (Daubenmire 1974). The Black Hills are also several hundred km distant from the nearest population of pure P. glauca in boreal North America.

The Picea forests in the Hills constitute the "subalpine" forests though alpine areas are absent here. Additionally, Abies is absent in the Hills; so the spruce-fir zone, typical of the Rocky Mountains generally, is represented in the Hills by spruce without the fir as a climax tree. Pinus contorta, also common in subalpine forests over much of the Rocky Mountains, has a very restricted distribution in the Hills, as discussed below.

Pinus ponderosa, Populus tremuloides, and Betula papyrifera are all common seral species in the Picea zone. Picea glauca rarely occurs in vegetation dominated by Pinus ponderosa or Populus tremuloides; it is not aggressive as a seral species though it appears to be expanding, or reintroducing, itself into certain areas (Figure 26).

The Picea glauca Series in the Black Hills constitutes a rather small fraction of the total forested area. It is important,

Figure 26. Typically, Populus tremuloides forms a fringe separating the Picea forests from parks. Here the Picea have begun to regenerate beyond the Populus into the park vegetation.

however, in representing the high elevation coniferous forests there. The Series also harbors certain undergrowth plants that accompanied Picea glauca to the Black Hills during Pleistocene time and became disjunct from their relatives in the Bighorn Mountains, Wyoming, or the Boreal forest in Canada.

Picea glauca/Linnaea borealis habitat type.---The Picea/ Linnaea h.t. occurs on slopes facing WNW to ENE (Figure 27). Pinus ponderosa and Populus tremuloides are seral species in most stands, though Picea glauca reproduces successfully and maintains its population as the climax dominant (Appendix Table A-1). Pinus ponderosa shows size class distributions indicative of a seral species gradually being replaced by another species. Populus tremuloides is present in some stands in only the small size classes with little evidence its population is expanding. Like Pinus ponderosa, Populus tremuloides is no doubt a carryover from the time of last disturbance of the Picea forests, and may always be a part of the Picea forests. Even in stands 40 and 52 which are more than 175 years old, remnants of Pinus and Populus populations still exist.

The undergrowth is dominated by Linnaea borealis (Figure 28). In all, 73 species occur in the undergrowth of this h.t. Average total coverage ranges from 49% to 139%. Species with constancies of 80% or more and their mean coverages are as follows:

Species	Constancy	Coverage
Arctostaphylos uva-ursi	80%	1.9%
Juniperus communis	100	6.7

Figure 27. Picea glauca/Linnaea borealis habitat type. Various size classes of Picea are present; some Pinus ponderosa are also present in this stand.

Figure 28. Linnaea borealis in flower in Stand 40. Fragaria virginiana and Oryzopsis asperifolia are also conspicuous in the photo.

Linnaea borealis	100%	19.3%
Rosa acicularis	100	2.6
Shepherdia canadensis	80	0.8
Symphoricarpos albus	100	0.8
Fragaria virginiana	100	2.6
Galium boreale	80	1.1
Hedysarum alpinum	80	0.4
Lichens and Mosses	100	17.0
Viola adunca	80	0.6
Oryzopsis asperifolia	80	4.9
Poa pratensis	80	1.6

Most of the above are also high constancy species in the Pinus/Arctostaphylos and Pinus/Juniperus communis h.ts. Those which are more characteristic of the Picea/Linnaea h.t. include L. borealis Shepherdia canadensis, and Hedysarum alpinum. Of these only Linnaea has sufficient coverage to make it easily visible. For practical purposes the combination of a self-maintaining population of Picea glauca, common to abundant Linnaea, and the absence of Vaccinium scoparium in the undergrowth serve to identify this habitat type. Linnaea has only 6.4% coverage and 28% frequency in Stand 52. These values are low among the stands sampled and Linnaea is somewhat less conspicuous in this stand. L. borealis is also an important species in Picea glauca-dominated forests in Canada (Eis 1981, LaRoi 1967, Moss 1952, 1955, Mueller-Dombois 1964). It is not an important species in Picea engelmannii-dominated forests of the Bighorn Mountains in Wyoming, the closest location to the Black Hills of Picea-dominated forests (Hoffman and Alexander 1976).

Edaphic characteristics of this h.t. are given in Appendix Table A-11.

Picea glauca/Vaccinium scoparium habitat type.---The Picea/ Vaccinium h.t. occurs on both limestone and igneous substrates. In general, it is found at somewhat higher elevations than other forest habitat types, though it overlaps the elevations of some. It occupies sites that are cool and moist. Picea is the sole climax dominant of the h.t., but the tree population is nearly always a mixture of Picea, _Pinus ponderosa_, and _Populus tremuloides_ (Figure 29). In some stands _Betula papyrifera_ is a low tree or tall shrub (Appendix Table A-1). In most of the stands sampled Picea is younger than 100 years. In stand 47 the largest Pinus and Picea are approximately 200 and 80 years respectively. Fire has been a factor in the ecology of these forests as it has in the _Pinus ponderosa_ forests. Forest management also has favored the aggressive Pinus which grows very well on _Picea glauca_ habitat types.

Vaccinium scoparium is the diagnostic and usually dominant undergrowth species (Figure 30). In stand 47 its coverage is only 2.3% and its frequency is 30%. Among the stands sampled, species with constancies of at least 80% and their mean coverages are the following:

Species	Constancy	Coverage
Arctostaphylos uva-ursi	80%	2.0%
Berberis repens	100	3.9
Juniperus communis	80	7.9
Pyrola secunda	80	0.6
Rosa acicularis	100	2.1
Spiraea betulifolia	80	6.4
Symphoricarpos albus	80	0.4
Vaccinium scoparium	100	20.0
Achillea millefolium	80	0.2

Figure 29. Picea glauca/Vaccinium scoparium habitat type. Pinus ponderosa is a seral species in this stand. The undergrowth is dominated by Vaccinium.

Figure 30. Undergrowth in Stand 46. Vaccinium scoparium, Berberis repens, Juniperus communis, Solidago sp., and Rosa acicularis are present in the photo. Note the abundance of Pinus ponderosa litter.

Antennaria plantaginifolia	80	0.7
Fragaria virginiana	100	0.8
Galium boreale	100	0.9
Hieracium umbellatum	80	0.7
Lathyrus ochroleucus	100	1.8
Lichens and Mosses	80	11.8
Thalictrum dioicum	80	0.2
Viola adunca	80	0.2
Oryzopsis asperifolia	100	5.5
Poa pratensis	80	1.2

In general, the undergrowth includes numerous species that have high constancies in other h.ts. in the Hills. Of the 19 species listed (mosses and lichens are counted as 1) only Pyrola secunda, Vaccinium scoparium, Hieracium umbellatum and Thalictrum dioicum are characteristic of this h.t. and of these 4 species only Vaccinium has sufficient coverage to be observed easily (Figure 30). The combination of a Picea population that is climax and an undergrowth dominated by Vaccinium scoparium serves to identify this h.t. in the Hills.

The Picea glauca/Vaccinium scoparium h.t. is the Black Hills variant of the Abies lasiocarpa/Vaccinium scoparium h.t. so common over much of the Rocky Mountains (Daubenmire and Daubenmire 1968, Hoffman and Alexander 1976, 1980, 1983, Oosting and Reed 1952, Pfister et al. 1977, Reed 1969, Steele et al. 1981), though, as indicated above, Abies is absent in the Black Hills. This has never been fully understood, but the low elevation and correspondingly warm temperatures of the Black Hills may be partially responsible for the lack of Abies. In the Bighorn Mountains, for example, the Picea engelmannii/Vaccinium scoparium h.t. occurs at somewhat lower elevation on warmer sites than the Abies lasiocarpa/Vaccinium scoparium h.t. Picea also occurs at high elevations on cold, moist sites with Abies, but the higher temperatures of

lower elevations may be limiting for Abies. The distribution of Abies is not the concern of the present study, but its absence is one of the unique characteristics of the Black Hills. Pseudotsuga menziesii is also absent, though it was introduced in 1942 in Palmer Gulch and has begun to "spread" in that immediate vicinity.

The Picea/Vaccinium and Picea/Linnaea h.ts. share numerous species. Among the high constancy species listed above, they share 63% of the total, using Jaccard's coefficient of similarity. The critical differences in the vegetation are seen in a relatively few significant species. Even the high constancy indicator species occur in other h.ts. but less frequently. Linnaea, Shepherdia, and Hedysarum all occur in the Picea/Vaccinium h.t. and Pyrola secunda, Hieracium umbellatum, and Thalictrum dioicum all occur in the Picea/Linnaea h.t.

In total species these two h.ts. are also very similar as shown:

	Picea/ Linnaea	Picea/ Vaccinium
Shrub Species	15	16
Forb Species	46	52
Graminoid Species	12	11
TOTAL	73	79

Edaphic characteristics of the Picea/Vaccinium h.t. are given in Appendix Table A-11.

KEY TO THE HABITAT TYPES

1. Conifers dominant and reproducing; angiosperms may be present but are seral.

   2. Pinus ponderosa present and reproducing; other conifers absent or not reproducing adequately to mainatain the population.

      3. Undergrowth dominated by Symphoricarpos albus, Amelanchier alnifolia and/or Rosa woodsii may be abundant. Balsamorhiza sagittata and Oryzopsis asperifolia absent or sparse...................Pinus ponderosa/Symphoricarpos albus h.t.

         4. Balsamorhiza sagittata common in the undergrowth; Oryzopsis asperifolia absent or rare..Pinus ponderosa/Symphoricarpos albus h.t. Balsamorhiza sagittata phase

         4. Oryzopsis asperifolia common in the undergrowth; Balsamorhiza sagittata absent or rare...........................Pinus ponderosa/Symphoricarpos albus h.t. Oryzopsis asperifolia phase

      3. Undergrowth dominated by species other than Symphoricarpos, Amelanchier, and/or Rosa.

         5. Undergrowth dominated by Juniperus scopulorum..........Pinus ponderosa/Juniperus scopulorum h.t.

         5. Juniperus scopulorum may be present but is not dominant in the undergrowth.

            6. Undergrowth dominated by Carex heliophylla..........Pinus ponderosa/Carex heliophylla h.t.

            6. Undergrowth not dominated by Carex heliophylla

               7. Undergrowth dominated by Physocarpus monogynus....Pinus ponderosa/Physocarpus monogynus h.t.

               7. Undergrowth not dominated by Physocarpus monogynus

                  8. Undergrowth dominated by Quercus macrocarpa...............................Pinus ponderosa/Quercus macrocarpa h.t.

                  8. Undergrowth not dominated by Quercus macrocarpa

                     9. Undergrowth dominated by Arcto-staphylos uva-ursi. Juniperus communis may be present, but not dominant.....Pinus ponderosa/Arctostaphylos uva-ursi h.t.

9. Undergrowth dominated by _Juniperus communis_, _Arctostaphylos uva-ursi_ may also be common................
.....*Pinus ponderosa*/*Juniperus communis* h.t.

2. _Picea glauca_ present and reproducing as the climax tree. _Pinus ponderosa_ may be present and abundant in seral communities.

10. Undergrowth dominated by _Linnaea borealis_. _Vaccinium scoparium_ absent or rare................
.....*Picea glauca*/*Linnaea borealis* h.t.

10. Undergrowth dominated by _Vaccinium scoparium_. _Linnaea borealis_ may be present......................
......*Picea glauca*/*Vaccinium scoparium* h.t.

1. Angiosperm deciduous species dominant and reproducing. Occasional conifers may be present.

11. Vegetation is shrub-steppe; _Cercocarpus montanus_ is dominant...
...... _Cercocarpus montanus_/_Bouteloua curtipendula_ h.t.

11. Vegetation is woodland or forest. _Cercocarpus montanus_ is absent or rare.

12. _Quercus macrocarpa_ dominant and reproducing overstory species. Other tree species absent or rare.

13. Undergrowth dominated by _Ostrya virginiana_...........
.... _Quercus macrocarpa_/_Ostrya virginiana_ h.t.

13. Undergrowth dominated by _Symphoricarpos occidentalis_..
.... _Quercus macrocarpa_/_Symphoricarpos occidentalis_ h.t.

12. _Populus tremuloides_ dominant and reproducing overstory species. _Quercus macrocarpa_ and/or other tree species rare or occasional.

14. Undergrowth dominated by _Corylus cornuta_, _Aralia nudicaulis_ and/or _Pteridium aquilinum_ may be present but not abundant........................
.... _Populus tremuloides_/_Corylus cornuta_ h.t.

14. Undergrowth dominated by either _Aralia_ _nudicaulis_ or _Pteridium_ _aquilinum_. _Corylus_ _cornuta_ is usually present.

    15. Undergrowth dominated by _Aralia_ _nudicaulis_ _Pteridium_ _aquilinum_ absent or not abundant.....
    .....*Populus* _tremuloides_/_Corylus_ _cornuta_ h.t.
    ~~Pteridium aquilinum~~ Aralia nudicaulis phase

    15. Undergrowth dominated by _Pteridium_ _aquilinum_. _Aralia_ _nudicaulis_ absent or not abundant.
    .....*Populus* _tremuloides_/_Corylus_ _cornuta_ h.t.
    Pteridium _aquilinum_ phase

OTHER VEGETATION TYPES

Pinus ponderosa/Prunus virginiana community.---This community apparently is limited to a few locations in the northern Hills. *P. ponderosa* is dominant and appears to be reproducing and maintaining successfully its population, and abundant *Prunus virginiana* and *Amelanchier alnifolia* characterize the undergrowth (Figure 31). Additional species that characterize the undergrowth include the following:

Berberis repens

Spirea betulifolia

Apocynum androsaemifolium

Because of its limited occurrence this is not designated a habitat type. Northward, in the Custer National Forest of southeastern Montana and northwestern South Dakota, we described a Pinus/Prunus h.t. that shares a number of species with the same community of the northern Hills (Hansen and Hoffman 1986). In the Hills it may represent another phase of the Pinus/Symphoricarpos h.t. described above. The community also has some similarities with the Pinus/Physocarpus h.t. in the southwest part of the Hills.

Pinus contorta/Vaccinium scoparium community.---*Pinus contorta* is limited to a small area of the Hills located west of Nahant. I examined stands of this community in Sections 20, 28, 29, 30, T3N, R3E, and also in Section 35, T3N, R2E. Farther west in this township, along Rd. 189, is more *Pinus contorta* some of which has been cut along with *Pinus ponderosa*. The extent of the species is still limited to a small area of the Hills, though no doubt it has been part of the Hills flora since at least the Pleistocene. Figure 32 is a diagram of a ridge

Figure 31. Community of Pinus ponderosa/Prunus virginiana in the northern Hills. Symphoricarpos albus is also abundant in the undergrowth. A Pinus/Prunus h.t. occurs north of the Hills in the Custer National Forest.

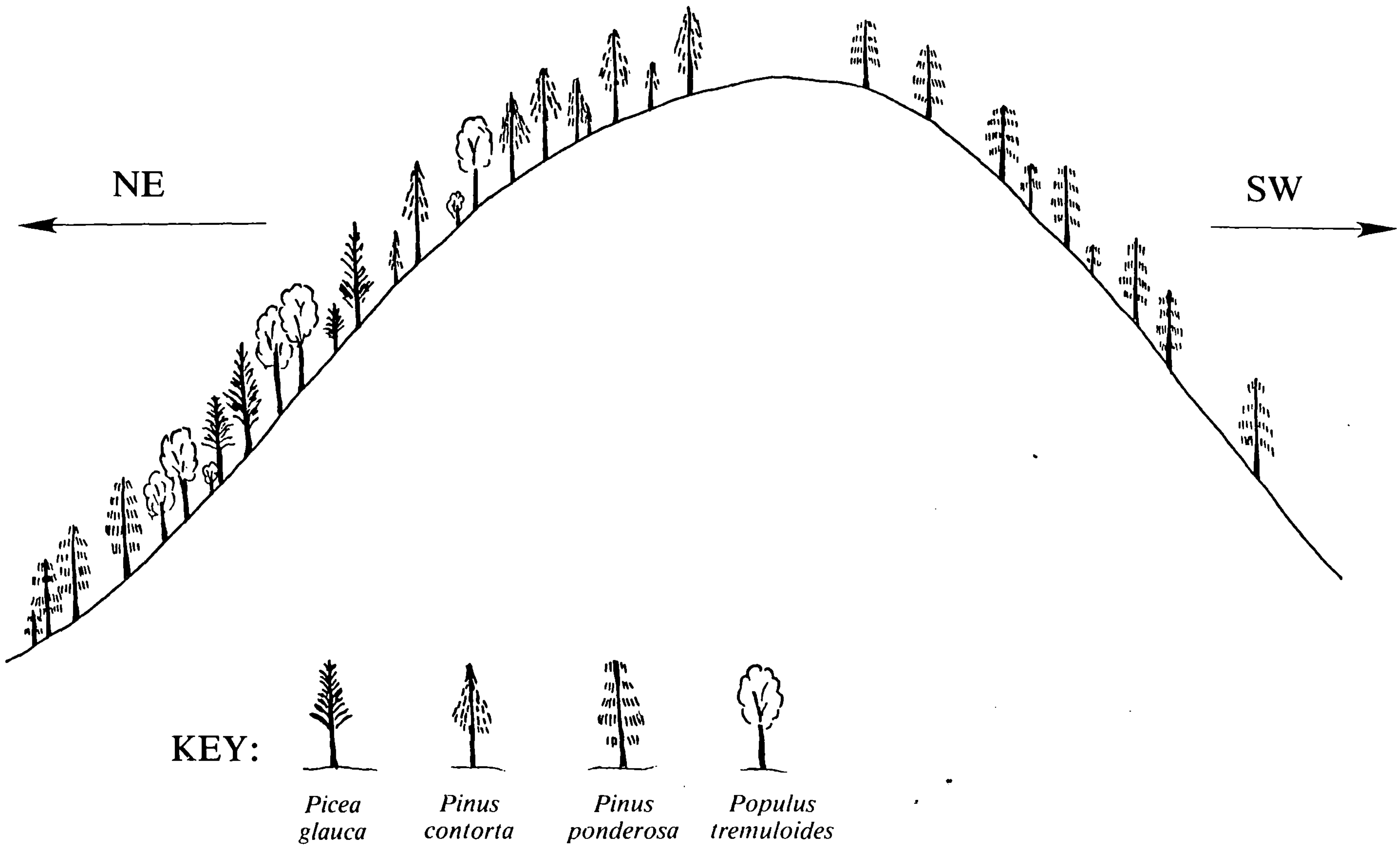

Figure 32. Diagram of ridge west of Nahant showing distribution of trees along northeast and southwest slopes. Forest is not well-developed along the crest of the ridge. Undergrowth species are omitted from the diagram.

south of Tillson Creek where the _Pinus contorta/Vaccinium scoparium_ community occurs. Other trees in the vicinity include _Picea glauca_, _Populus tremuloides_, and _Pinus ponderosa_ on the NE slope and only _Pinus ponderosa_ on the SW slope. The _Pinus contorta_ community is best developed along the upper part of the ridge just below the crest. I consider Vaccinium to be an important indicator species in this community. _Pinus contorta_ is rather dense and reproducing in this location and appears to be a climax species. Other undergrowth species include the following:

Arctostaphylos uva-ursi
Berberis repens
Juniperus communis
Rosa acicularis
Rubus ideaus
Spirea betulifolia
Symphoricarpos albus
Anemone patens
Arnica cordifolia
Campanula rotundifolia
Clematis tenuifolia
Galium boreale
Lathyrus ochroleucus
Vicia americana
Oryzopsis asperifolia
Schizachne purpurascens

Some of the above are more abundant in open areas with greater light intensity.

Pinus flexilis community.---A very small community of *Pinus flexilis* occurs in the Cathedral Spires area of the central Hills. Its location is NW¼ Sec. 28, T25, R5E. Most of the trees are on very steep north-facing slopes and rather inaccessible. *Pinus ponderosa* and *Picea glauca* are also present in the area. Scattered, small-statured *Populus tremuloides* and *Betula papyrifera* are also present. The undergrowth is relatively scattered and not abundant. Representative undergrowth species are *Juniperus communis*, *Arctostaphylos uva-ursi*, *Agrostis scabra*, *Carex concinna*, *Campanula rotundifolia*, *Woodsia oregana* and others (Thilenius 1970).

Salix communities.---These once were widespread along the stream courses throughout the Hills (Figures 22, 33). They are much reduced at the present time. Possibly disease and/or insects decimated some populations of Salix spp. as noted by Froiland (1962). It is at least as likely that animals, directly or indirectly, have eliminated much of the Salix in the Hills. Animals grazing or loitering or just moving back and forth to a water supply can retard or eventually stop regeneration of these streamside communities. Most photos that compare early to modern vegetation show streamside shrub communities were more abundant and more dense before the arrival of caucasians and their animals.

Riparian forest communities.---Some of the larger streams in the Hills supported riparian forests dominated by species of Ulmus, Fraxinus, Acer, and Celtis. Occasionally a conifer

or Quercus macrocarpa was part of this vegetation. Close to the larger streams Populus deltoides formed a pioneer community. Most of this vegetation no longer exists. Near "Ranch A" along the South Dakota-Wyoming border, south of Beulah, large trees are still present along the stream. The undergrowth is now altered and most of the shrubs and young trees are gone. The large trees will be replaced only if planted as there is no regeneration in that location. Custer State Park provides the best examples of riparian vegetation which may perpetuate itself.

None of the above vegetation types were evaluated in detail in this study. Additionally, grassland vegetation of the Hills was not a part of this study.

DISTRIBUTION OF TREE SPECIES IN THE BLACK HILLS

Pinus ponderosa is easily the most prominent tree in the Hills. It is climax over vast areas from low to high elevations, and where it is not climax it can be an important seral species (Table 1). Pinus ponderosa is an aggressive species and it moves on to Picea glauca h.ts. after the latter have been disturbed. It is a major seral species on both the Picea glauca/ Linnaea borealis and Picea glauca/Vaccinium scoparium h.ts. It even occurs along major streams as an occasional species in Quercus macrocarpa-dominated vegetation. Picea glauca is not aggressive; it is an occasional species in only a few other h.ts. Populus tremuloides is a climax species in some areas

Table 1. The ecologic roles of tree species in the habitat types of the Black Hills National Forest. C = Climax; S = major seral; S = minor seral; o = occasional.

Habitat Type \ Species	Fraxinus pennsylvanica	Ulmus rubra	Quercus macrocarpa	Betula papyrifera	Populus tremuloides	Pinus ponderosa	Picea glauca
Quercus macrocarpa/ Ostrya virginiana	o	o	C			o	
Quercus macrocarpa/ Symphoricarpos occidentalis			C				
Pinus ponderosa/ Juniperus scopulorum							
Pinus ponderosa/ Carex heliophila			s			C	o
Pinus ponderosa/ Symphoricarpos albus[a]			o			C	
Pinus ponderosa/ Physocarpus monogynus						C	
Pinus ponderosa/ Quercus macrocarpa[b]			C			C	
Pinus ponderosa/ Juniperus communis			s	o	S	C	o
Pinus ponderosa/ Arctostaphylos uva-ursi			o	o	S	C	o
Populus tremuloides/ Corylus cornuta[a]			s	c	C	o	o
Picea glauca/ Linnaea borealis				s	S	S	C
Picea glauca/ Vaccinium scoparium				s	s	S	C

[a]Phases of these h.ts. have no tree species with status different than in typal phases. A few Betula papyrifera occur in Stand 32, Pinus ponderosa/ Symphoricarpos albus h.t. Oryzopsis asperifolia phase.

[b]In this h.t. Quercus macrocarpa is a shrub.

of the Hills, and it is a conspicuous seral species in certain h.ts. dominated by *Pinus ponderosa* and *Picea glauca*. As in much of the Rocky Mountain region, Populus in the Black Hills follows fire on several h.ts. It is a major seral species in *Pinus ponderosa*/*Juniperus communis*, *Pinus ponderosa*/*Arctostaphylos uva-ursi*, and *Picea glauca*/*Linnaea borealis* h.ts.

Quercus macrocarpa occurs mainly along the northern fringe of the Hills, but it is also a sizeable tree along some streams in the central Hills. It occurs as far south as French Creek in Custer State Park. Along the northern fringe of the Hills it is relatively small-statured and forms dense stands with a physiognomy similar to that of *Quercus gambelii* of the central Rocky Mountains. It also is an undergrowth shrub in certain stands of *Pinus ponderosa*.

Quercus is another species that spread during the periods of uncontrolled fires. It moved onto both *Pinus ponderosa*- and *Populus tremuloides*-dominated h.ts. and it still is present in some of these h.ts.

Betula papyrifera occurs mainly as a sub-dominant in stands of *Populus tremuloides*. Like Populus, Betula is present as a seral species following disturbance of *Picea glauca*- and more mesic *Pinus ponderosa*-dominated vegetation.

Fraxinus pennsylvanica and *Ulmus rubra* are members of a riparian vegetation complex not studied here, but a few seedlings of both occur in *Quercus macrocarpa*-dominated vegetation. Other deciduous angiosperm trees are not reported here though they occur also in the riparian forests.

SPECIES RICHNESS

Species richness of the undergrowth vegetation for all h.ts. is given in Table 2. Median numbers per stand (125 m^2 central macroplot) range from 11 in the Pinus/ Carex h.t. to 36 in the Pinus/ Quercus h.t. Because some h.ts. were sampled in more stands than others, care is taken is comparing and evaluating species richness. Most of the following discussion omits the Quercus/ Symphoricarpos and Pinus/ J. scopulorum h.ts. each of which is represented by just one stand.

In general, fewer species occur in more xeric h.ts. As I have grouped them they are Pinus/ Carex, Pinus/ Physocarpus, Pinus/ J. communis, and Cercocarpus/ Bouteloua h.ts. The range of median numbers is 11 to 18. Pinus/ J. scopulorum had only 13 species in the stand sampled. A second, less xeric, group of h.ts. include Pinus/ Symphoricarpos, Pinus/ Arctostaphylos, and Quercus/ Ostrya. The range of median numbers for this group is 20 to 22.5. There were 20 species in the one stand of Quercus/Symphoricarpos. The third group of h.ts., possibly the most mesic, include Pinus/ Quercus, Populus/Corylus, Picea/ Linnaea, and Picea/ Vaccinium. The range of median species numbers is 31 to 36. The above groupings are arbitrary in the sense they are based solely on one criterion, and exceptions to the groups are obvious. The Pinus/Physocarpus and Pinus/ J. communis h.ts. are more mesic than their positions above indicates. The Pinus/ Physocarpus h.t. occurs on N-NNW facing slopes on topographic positions with more moisture than those supporting the Pinus/ Symphoricarpos h.t. Additionally, the

Table 2. Species richness of undergrowth vegetation in Black Hills habitat types.

Habitat Type	Number of stands sampled	Median number of Undergrowth Shrubs[a]	Herbs[a]	Range of Numbers[a]
Pinus ponderosa/ Juniperus scopulorum	1	2	11	--
Pinus ponderosa/ Carex heliophila	3	3	8	9 - 18
Cercocarpus montanus/ Bouteloua curtipendula	3	4	14	17 - 19
Pinus ponderosa/ Physocarpus monogynus	3	8	8	13 - 21
Pinus ponderosa/ Juniperus communis	7	6	11	14 - 27
Quercus macrocarpa/ Ostrya virginiana	5	4	16	15 - 42
Quercus macrocarpa/ Symphoricarpos occidentalis	1	7	13	--
Pinus ponderosa/ Arctostaphylos uva-ursi	10	5	16	13 - 29
Pinus ponderosa/ Symphoricarpos albus[b]	12	7	15	14 - 28
Pinus ponderosa/ Quercus macrocarpa	4	7	29	27 - 44
Populus tremuloides/ Corylus cornuta[b]	9	11	24	26 - 44
Picea glauca/ Linnaea borealis	5	8	23	14 - 36
Picea glauca/ Vaccinium scoparium	5	8	25	20 - 41

[a]Numbers based on sampling 125 m^2 per stand.

[b]Numbers include those of the habitat type phases also.

Pinus/ J. communis h.t. has Populus tremuloides as a major seral species and both Betula papyrifera and Picea glauca as occasional trees. Indeed, there is evidence that some stands considered to be Pinus/ J. communis h.t. are in fact seral to Picea glauca-dominated vegetation.

The number of shrub species in the undergrowth may reflect more closely a xeric to mesic gradient among the h.ts. As shown in Table 2 the most xeric h.ts. have 2 to 4 shrub species. The most mesic, those dominated by Populus tremuloides and Picea glauca, have 8 to 11 shrub species. Pinus/ Physocarpus with just 16 (median) undergrowth species also has 8 shrubs. This more closely indicates its moisture relations, along with topographic position as indicated above. If this line of evidence holds the Pinus/ J. communis h.t. with 6 undergrowth shrubs is among a group with intermediate numbers of shrubs.

Obviously a single ecosystem characteristic such as species richness may or may not reflect accurately one factor like moisture relations. The above discussion is intended primarily to point out the range of undergrowth species among the h.ts. and provide a point of departure for further study.

SOME PRACTICAL CONSIDERATIONS

Though it is a basic approach to land and vegetation classification, the habitat type concept has practical value to land managers. Daubenmire (1961) showed it to be useful in predicting growth rates of Pinus ponderosa in the northern Rockies. In a preliminary study in the Black Hills Rioux (1984) showed significant differences in growth rates of Pinus ponderosa among some of the habitat types there. Her results suggest that further study would be worthwhile in clarifying the range of growth rates of this species among the forest habitat types in the Black Hills.

Considerably more information would have come from the study of Thilenius (1972) had the habitat types been known then. A grouping of sites, selected on the basis of deer usage, will produce no more than a hierarchy based on apparent effects of deer use. The relation of deer use to habitat type, however, could at least produce results on the biotic potential of the sites utilized.

The potential use of habitat types in the Black Hills to indicate grazing potentials has yet to be studied. A few studies have been done on production and nutritive value of forest undergrowth species (Kranz and Linder 1973, Pase 1958, Pase and Hurd 1957, Severson 1982). How the undergrowth of various habitat types responds to logging, thinning, and/or fire has yet to be studied. Results of such a study could relate directly to grazing potentials of disturbed sites of habitat types. Certainly most of the forested area of the Hills is in some stage of secondary succession.

LONG-TERM VEGETATIONAL CHANGES

Graves (1898) indicated that uncontrolled fires during the 1800's, and probably earlier, destroyed much of the timber in the Black Hills, especially *Pinus ponderosa* forests. Repeated fires left the forest "...irregular and broken, and composed in many places of defective and scrubby trees..." (Graves 1898). Early records of the Black Hills flora and vegetation have essentially no quantitative data. Photographic records are often the best one can find in assessing long-term vegetational changes. The Custer expedition into the Black Hills in 1874 was documented in part by photographs. In 1974 a number of the photographic sites were relocated and new photos taken to show changes in the vegetation (Figure 33). From the photos it is apparent that with fires mainly controlled, succession has resulted in clearly more dense stands of vegetation. The stand of *Populus tremuloides* in the right of Figure 33 not only has developed to become a mature stand, it also shows little evidence of change toward a conifer-dominated stand.

It is of interest also that riparian vegetation, once common along most streams in the Hills, has been greatly reduced in making more herbaceous vegetation available for domestic animals.

Figure 33a. Picture taken of one of the Custer camps, Custer expedition of 1874. View is upstream at Castle Creek. Note the sparse forest vegetation on the slopes in the background. Pieces of laundry spread on the shrubs are visible in the foreground.

b. Same location, photo was taken in 1974. Control of fire, primarily, has allowed forests to develop. Stand of _Populus tremuloides_ on the right has matured and is probably climax at that location. The riparian willow vegetation, evident in the foreground in 1874 photo, is completely gone in the 1974 photo. These photos were loaned courtesy of South Dakota State University.

a

b

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APPENDIX TABLES

Table A-1 Tree population structure of each species in each stand listed by habitat type. Number of trees listed are per 375 m^2; basal area (b.a.) in m^2/ha is given below each stand number. Abbreviations of tree species are the following:

Pc g --- <u>Picea glauca</u>
Pn p --- <u>Pinus ponderosa</u>
Po t --- <u>Populus tremuloides</u>
Be p --- <u>Betula papyrifera</u>
Qu m --- <u>Quercus macrocarpa</u>
Ju s --- <u>Juniperus scopulorum</u>
Os v --- <u>Ostrya virginiana</u>
Ul r --- <u>Ulmus rubra</u>
Fr p --- <u>Fraxinus pennsylvanica</u>

Stand and b.a.	Species	Diameter (at breast height) classes in dm: 0-1 <.5	0-1 >.5	1-2	2-3	3-4	4-5	5-6	6-7
		Picea glauca / Vaccinium scoparium h.t.							
47 32.5	Pc g	51	11	3	4	4			
	Pn p	1		3	1	2		1	
46 50.8	Pc g					1			
	Pn p		4	10	23	5			
	Be p	22	1						
	Po t	55							
9 40.5	Pc g	9		1	2	1			
	Pn p			4	13	6			
	Po t	23		1					
51 52.9	Pn p		7	27	10	2	2	2	
	Po t	38							
48 38.3	Pc g	623	5	11	17	4			
	Po t	45							

Table A-1, cont'd

Stand and b.a.	Species	Diameter (at breast height) classes in dm: 0-1 < .5	0-1 >.5	1-2	2-3	3-4	4-5	5-6	6-7
		<u>Picea glauca</u> / <u>Linnaea borealis</u> h.t.							
15 41.8	Pc g	38	8	9	5				
	Pn p	1	3	22	7	2	1		
	Po t	8	1	1					
40 30.6	Pc g	336	9	6	4	3	1		
	Pn p			1	1	1	1		
	Po t	14	1						
52 56.6	Pc g	75	19	20	9	1		2	
	Pn p	10		1	5	4			
50 47.2	Pc g	30	2		4	3			
	Pn p		1	9	7	8			
60 35.5	Pc g	112	23	22	8	2			
	Pn p			2	3	1			
		<u>Populus tremuloides</u> / <u>Corylus cornuta</u> h.t.							
67 30.4	Po t	513	12	10	7	2			
	Be p	48	10	7					
	Qu m	16	1		2	1			
69 27.6	Po t	298	9	3	3	4			
	Be p	2	5	8	5				
55 30.4	Po t	78			8	6	1		
	Be p	8		1					
	Qu m	53							
	Pc g	8							

Table A-1, cont'd

Stand and b.a.	Species	Diameter (at breast height) classes in dm 0-1 <.5	0-1 >.5	1-2	2-3	3-4	4-5	5-6	6-7
2 28.7	Po t	20	4	5	5				
	Be p	23	26	27					
	Qu m	54	4	2	1				
	Pn p	8		1					
30 33.7	Po t		2	19	4	4			
	Be p	63	30	7					
	Pn p	1			1				
	Qu m	1							
31 28.9	Po t	11	7	7	5	1			
	Be p	16	11	8	4	2			
	Pn p	1							
	Populus / Corylus h.t., _Pteridium_ _aquilinum_ phase								
25 41.7	Po t	255		23	21				
26 52.3	Po t	12		6	28	5			
	Qu m	23							
	Pn p	9							
	Populus / Corylus h.t., _Aralia_ _nudicaulis_ phase								
43 33.0	Po t	105		8	9	1			
	Be p	50	20	26					
	Qu m	60							
	Pinus _ponderosa_ / _Juniperus_ _communis_ h.t.								
1 46.1	Pn p	67	12	22	11	6	1		
	Po t	1							
5 29.4	Pn p	217	1	3	2	4	2	1	

Table A-1, cont'd

Stand and b.a.	Species	Diameter (at breast height) classes in dm 0-1 <.5	>.5	1-2	2-3	3-4	4-5	5-6	6-7
7 40.1	Pn p	82	17	11	5	1	2	1	1
	Po t	45							
8 32.0	Pn p	23	4	8	5	4		1	
	Pc g		2	3		1			
	Po t	55							
	Be p	1							
29 28.7	Pn p	3	5	6	3	5	2		
38 29.8	Pn p		7	18	2	2	3		
53 50.2	Pn p	1	3	12	11	10	1		
	Pinus ponderosa / *Arctostaphylos uva-ursi* h.t.								
16 47.1	Pn p	22	11	39	15	3			
	Po t	1							
17 42.4	Pn p	258	38	34	8	2	1		
18 48.2	Pn p	38	4	17	16	4	2		
19 46.1	Pn p	70		4	24	5			
	Po t	9							
34 38.4	Pn p	605	81	4	9	3			
37 41.2	Pn p	10	6	15	9	1	3	1	
	Po t	8							
41 31.4	Pn p	360	4	2	3	5	3		

Table A-1, cont'd

Stand and b.a.	Species	Diameter (at breast height) classes in dm 0-1 <.5	0-1 >.5	1-2	2-3	3-4	4-5	5-6	6-7
62 44.1	Pn p	831	9		2	5	4	1	
	Qu m	15							
66 25.2	Pn p	78	2	2	2	5	2		
70 33.9	Pn p	11	2	21	11	2	1		
Pinus ponderosa / *Physocarpus monogynus* h.t.									
57 33.9	Pn p	1470		7	14	4			
64 45.5	Pn p	19	36	54	10	1			
	Ju s	1							
65 33.8	Pn p	15	4	29	15				
Pinus ponderosa / *Carex heliophila* h.t.									
49 47.4	Pn p		4	21	18	5			
	Qu m	39	2	1					
23 37.8	Pn p	896	1	3	4	8	2		
63 48.5	Pn p	23		4	23	4		1	
Pinus ponderosa / *Juniperus scopulorum* h.t.									
58 17.8	Pn p	207	4	8	3	1			
	Ju s	87	27	22	7				
Pinus ponderosa / *Quercus macrocarpa* h.t.									
28 31.3	Pn p	15	1	5	14		1	1	
27 42.2	Pn p	90		4	4	2	2	2	1

Table A-1, cont'd

Stand and b.a.	Species	Diameter (at breast height) classes in dm: 0-1 <.5	0-1 >.5	1-2	2-3	3-4	4-5	5-6	6-7
44 36.9	Pn p	4	4	20	7	2		2	
68 34.3	Pn p	833		4	15	5			
		Pinus ponderosa / *Symphoricarpos albus* h.t.							
12 44.5	Pn p	35	32	34	10	1	2		
	Qu m	44							
14 30.8	Pn p	8	1	11	6	5	1		
	Pc g		1	1					
21 34.8	Pn p	15	17	30	5	3	1		
39 31.3	Pn p	1795			4	5	1		1
42 32.9	Pn p			31	12	1			
54 41.3	Pn p	9	17	10		1	6	1	
	Qu m	9							
59 38.3	Pn p	2	6	14	10	2	3		
		Pinus / Symphoricarpos h.t., *Oryzopsis asperifolia* phase							
24 37.1	Pn p	81	45	32	7			1	
	Qu m	9	1						
32 33.8	Pn p	2727	6	2	4	2	1	2	
	Be p		1	2					
6 37.1	Pn p	183	35	19	1		2	2	

Table A-1, cont'd

Stand and b.a.	Species	Diameter (at breast height) classes in dm 0-1 <.5	0-1 >.5	1-2	2-3	3-4	4-5	5-6	6-7
Pinus / Symphoricarpos h.t., Balsamorhiza sagittata phase									
13 32.2	Pn p	59	12	8	10	2	2		
61 35.8	Pn p	219	10	16	10	2			1
Quercus macrocarpa / Symphoricarpos occidentalis h.t.									
3 25.7	Qu m	383	13	32	5	1			
Quercus macrocarpa / Ostrya virginiana h.t.									
45 31.5	Qu m	30	5	21	6				
	Pn p		1	2	2				
	Fr p	9	1						
	Ul r		3	1					
	Os v	1043	52	1					
11 24.0	Qu m	45		3	3				
	Os v	3000 [a]	57	25					
10 24.7	Qu m	68	1	19	3	1			
	Os v	3000	57	3					
4 30.2	Qu m	405			5	3			
	Fr p	8							
	Os v	1733	55	19					
20 22.8	Qu m	32	4	7	1		1		
	Be p	42	4	6					
	Pn p	25							
	Os v	3000	45	1					
	Ul r	40							

[a]The number 3000 is used to approximate seedling numbers where seedlings were too dense to count accurately in a reasonable time period.

Table A-2. Coverage (C) and frequency (F) of undergrowth species in stands of *Cercocarpus montanus* / *Bouteloua curtipendula* habitat type. Coverage of less than 0.5% is indicated by +. Species present in the macroplot but absent from the microplots are indicated by *. Stand numbers, locations, and topographic positions are also given.

Stand Number	35	36	56
Location:			
Quarter	SW	NW	NE
Section	9	32	18
Township	5S	5S	3S
Range	2E	6E	1E
Topographic Position			
Slope, degrees	21	38	32
Aspect, degrees	140	80	82
Elevation, m	1463	1265	1493
Coverage, % / Frequency, %	C / F	C / F	C / F
SHRUBS			
Artemisia frigida	1.3 / 6.0	0.8 / 6.0	0.6 / 4.0
Cercocarpus montanus	45. / 95.	41. / 90.	41. / 90.
Gutierrezia sarothrae	1.1 / 6.0	5.2 / 22.	.
Juniperus scopulorum	.	.	4.6 / 26.
Rhus aromatica	1.7 / 2.0	6.7 / 18.	8.4 / 22.
FORBS			
Allium sp.	+ / 2.0	.	*
Argemone polyanthemos	*	.	.
Artemisia ludoviciana	.	2.2 / 30.	.

Table A-2, cont'd.

Stand Number	35	36	56
Aster oblongifolius	0.9/16.	3.3/28.	*
Astragalus gracilis	+/2.0	.	.
Cryptantha celosiodes	+/2.0	.	.
Euphorbia fendleri	*	.	+/2.0
Evolvulus nuttallianus	+/4.0	.	.
Hedeoma hispida	2.0/34.	2.6/30.	2.2/30.
Helianthus maximiliana	.	*	.
Linum perenne	.	.	2.3/32.
Lithospermum incisum	0.8/14.	.	.
Mentzelia oligosperma	.	0.8/6.0	.
Mosses & Lichens	+/4.0	.	.
Opuntia polyacantha	+/2.0	.	.
Phlox hoodii	.	.	0.6/16.
Polygala alba	*	+/14.	.
Sphaeralcea coccinea	.	.	+/12.
Tragopogon dubius	.	+/2.0	.
Yucca glauca	.	*	3.2/8.0

Table A-2, cont'd.

Stand Number	35	36	56
GRAMINOIDS			
Agropyron dasystachyum	+ / 4.0	.	.
Andropogon scoparius	.	.	2.7 / 8.0
Aristida longiseta	3.5 / 28.	+ / 4.0	+ / 4.0
Bouteloua curtipendula	24. / 70.	37. / 88.	29. / 76.
Bromus japonicus	.	+ / 12.	*
Carex filifolia	+ / 4.0	*	.
Oryzopsis hymenoides	2.1 / 8.0	1.0 / 4.0	1.7 / 12.
Oryzopsis micrantha	.	10. / 28.	3.6 / 12.
Sitanion hystrix	4.2 / 34.	2.0 / 14.	+ / 2.0
Sporobolus cryptandrus	.	1.3 / 6.0	.
Stipa comata	.	9.5 / 42.	0.7 / 2.0
Species in microplots	19	18	17
Coverage of shrubs	49	54	55
Coverage of forbs	5	9	9
Coverage of graminoids	34	61	38
Total coverage	88	124	102

Table A-3. Coverage (C) and frequency (F) of undergrowth species in stands of Quercus macrocarpa / Symphoricarpos occidentalis and Quercus macrocarpa / Ostrya virginiana habitat types. Coverage of less than 0.5% is indicated by +. Species present in the macroplot but absent from the microplots are indicated by *. Stand numbers, locations, and topographic positions are also given.

	Quercus/ Symphoricarpos		Quercus / Ostrya			
Stand Number	3	45	11	10	4	20
Location						
Quarter	SE	NE	NE	SE	SW	SE
Section	13	16	18	7	19	14
Township	6N	52N	6N	6N	6N	1N
Range	3E	60W	4E	4E	4E	6E
Topographic position						
Slope, degrees	16	16	25	18	14	29
Aspect, degrees	84	90	10	334	320	334
Elevation, m	1280	1250	1158	1067	1158	1140
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F
SHRUBS						
Amelanchier alnifolia	4.6/42.	.	.	.	.	5.0/18.
Berberis repens	12./64.	+/8.0	.	1.2/16.	1.3/12.	+/8.0
Cornus stolonifera	.	.	.	.	.	*
Corylus cornuta	.	.	.	.	.	3.0/6.0
Crataegus succulenta	.	.	.	.	.	*
Juniperus communis	.	.	.	.	.	3.9/20.
Lonicera dioica	.	.	.	.	.	2.3/14.
Physocarpus opulifolius	.	.	.	.	.	+/6.0
Prunus virginiana	11./58.	+/2.0	.	7.1/34.	14./76.	4.0/26.

Table A-3, cont'd.

Stand Number	3	45	11	10	4	20
Ribes sp.	0.8 / 2.0	+ / 2.0	*	*	+ / 2.0	4.1 / 20.
Rosa acicularis	0.9 / 6.0	*	.	.	.	+ / 2.0
Rubus idaeus	4.8 / 38.	.	.	.	.	.
Shepherdia canadensis	.	.	.	.	.	*
Spiraea betulifolia	0.9 / 14.	.	.	.	+ / 4.0	10. / 40.
Symphoricarpos albus	.	.	.	.	.	4.1 / 38.
Symphoricarpos occidentalis	12. / 68.	0.6 / 14.	*	0.6 / 12.	11. / 74.	.
Toxicodendron rydbergii	2.8 / 36.	+ / 2.0	.	*	.	6.0 / 28.
FORBS						
Achillea millefolium	.	.	.	*	+ / 2.0	0.6 / 14.
Actaea rubra	.	.	.	.	.	*
Antennaria plantaginifolia	.	.	.	.	.	+ / 2.0
Apocynum androsaemifolium	.	.	.	.	.	+ / 6.0
Aquilegia canadensis	.	.	.	.	.	1.0 / 10.
Arabis divaricata	.	.	.	.	.	+ / 2.0
Aralia nudicaulis	.	.	.	.	.	12. / 56.

Table A-3, cont'd.

Stand Number	3	45	11	10	4	20
Arenaria lateriflora	.	.	.	.	.	+/8.0
Arnica rydbergii	.	.	.	.	.	+/2.0
Aster ciliolatus	.	.	.	.	.	1.5/18.
Campanula rotundifolia	.	.	.	.	.	+/2.0
Cerastium nutans	.	.	*	+/4.0	.	0.7/6.0
Delphinium nuttallianum	*	.	0.9/26.	1.5/4.0	+/6.0	.
Disporum trachycarpum	.	*	+/4.0	.	1.7/40.	1.9/36.
Dodecatheon pauciflorum	.	.	+/4.0	.	.	*
Dodecatheon pulchellum	.	.	1.2/8.0	.	.	.
Erigeron philadelphicus	.	.	.	.	.	*
Fragaria virginiana	.	*	.	.	+/2.0	*
Galium aparine	1.9/27.	.	2.0/32.	2.0/38.	0.7/18.	.
Galium boreale	3.5/62.	*	.	+/8.0	.	1.8/30.
Galium triflorum	.	+/6.0	.	.	1.7/30.	+/6.0
Hackelia deflexa	.	+/4.0	.	.	.	.
Heuchera richardsonii	.	.	.	.	+/2.0	+/4.0

Table A-3, cont'd.

Stand Number	3	45	11	10	4	20
Lathyrus ochroleucus	1.5/22.	.	.	+/6.0	1.9/26.	4.0/48.
Lithophragma parviflora	.	.	2.0/44.	.	.	.
Maianthemum canadense	.	.	.	.	.	4.7/48.
Mertensia lanceolata	.	.	0.9/6.0	.	.	.
Microsteris gracilis	.	.	1.5/40.	2.5/50.	.	.
Monarda fistulosa	.	*	.	.	.	.
Montia perfoliata	.	.	+/2.0	.	.	.
Orobanche fasciculata	.	.	+/4.0	.	.	.
Osmorhiza chilensis	.	.	.	.	2.0/32.	.
Osmorhiza longistylis	.	+/2.0	.	.	.	0.7/6.0
Osmorhiza sp.	.	*	.	.	.	.
Parthenocissus vitacea	.	+/14.	.	.	.	.
Polygonatum biflorum	.	.	.	.	.	*
Sanicula marilandica	.	.	.	.	+/2.0	9.5/8.0
Senecio integerrimus	.	.	+/4.0	*	.	.
Smilacina racemosa	.	.	.	.	.	*

Table A-3, cont'd.

Stand Number	3	45	11	10	4	20
Smilacina stellata	+/10.	0.7/6.0	+/8.0	1.3/22.	+/12.	5.3/56.
Smilax herbacea	.	*	.	.	.	.
Taraxacum officinale	.	.	0.9/14.	0.7/8.0	.	0.7/8.0
Thalictrum dasycarpum	0.7/6.0	+/2.0	.	+/8.0	.	0.8/10.
Trifolium repens	.	.	.	+/6.0	.	.
Vicia americana	+/2.0	.	.	.	+/2.0	+/2.0
Viola adunca	.	.	.	.	.	+/4.0
Viola sp.	+/6.0	2.0/30.	.	*	.	.
Woodsia scopulina	.	.	2.4/24.	+/6.0	0.9/10.	*
GRAMINOIDS						
Agrostis hyemalis	.	.	1.0/10.	.	.	0.8/4.0
Bromus inermis	.	.	.	.	.	2.2/18.
Carex blanda	.	.	*	+/2.0	.	.
Carex foenea	9.4/58.	.	+/2.0	21./80.	22./86.	5.4/58.
Carex saximontana	.	.	1.7/16.	+/6.0	.	0.8/10.
Carex sp.	.	2.2/20.	.	.	.	.

Table A-3, cont'd

Stand Number	3	45	11	10	4	20
Carex sprengelii	3.5/18.	*	*	0.8/2.0	.	.
Elymus virginicus	.	1.4	.	10.	.	.
Festuca sp.	.	.	1.2/16.	.	.	.
Melica subulata	1.8/16.	.	.	.	.	.
Oryzopsis asperifolia	.	+/2.0	.	.	*	3.4/48.
Poa pratensis	5.5/38.	.	*	5.8/30.	1.2/16.	.
Schizachne purpurascens	.	.	.	.	*	2.5/30.
Species in microplots	20	15	18	20	20	42
Coverage of shrubs	50	1	--	9	27	43
Coverage of forbs	8	4	13	9	10	47
Coverage of graminoids	20	4	4	38	23	15
Total Coverage	78	9	17	56	59	105

Table A-4. Coverage (C) and frequency (F) of undergrowth species in stands of Pinus ponderosa / Symphoricarpos albus habitat type, including the Oryzopsis asperifolia and Balsamorhiza sagittata phases. Coverage of less than 0.5% is indicated by +. Species present in the macroplot but absent from the microplots are indicated by *. Stand numbers, locations, and topographic positions are also given

	Pinus / Symphoricarpos ht.							Oryzopsis phase			Balsamorhiza phase	
Stand Number	12	14	21	39	42	54	59	24	32	6	13	61
Location												
Quarter	NW	SE	NW	SE	SW	NW	NE	NE	SE	NW	SE	NE
Section	14	29	22	30	11	33	21	34	22	33	36	26
Township	51N	1N	1N	5S	3S	5N	1N	1S	3S	4N	51N	2S
Range	51W	3E	3E	6E	1E	5E	3E	6E	6E	5E	61W	1E
Topographic position												
Slope, degrees	32	17	11	30	31	24	21	16	24	2	9	2
Aspect, degrees	254	40	54	20	34	90	268	316	336	46	248	--
Elevation, m	1440	1768	1813	1288	1562	1356	1820	1372	1432	1509	1646	1817
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
SHRUBS												
Amelanchier alnifolia	0.7/8.0	*	0.9/16.	0.7/8.0	1.1/14.	6.3/36.	.	0.7/16.	+/2.0	3.2/24.	3.6/34.	.
Amelanchier humulis	.	.	.	.	.	.	1.7/2.0	.	.	.	.	+/2.0
Arctostaphylos uva-ursi	+/6.0	3.1/34.	6.3/16.	.	.	1.3/12.	.	2.8/22.	.	5.0/56.	+/10.	4.6/16.
Berberis repens	4.4/54.	.	.	.	.	4.6/22.	.	.	.	7.3/66.	4.1/54.	+/2.0
Ceanothus velutinus	.	.	.	.	.	+/2.0	.	.	.	.	.	.
Juniperus communis	*	.	*	+/2.0	14./24.	.	.	.	.	.	*	.
Juniperus scopulorum	.	.	.	2.5/4.0	*	.	.	.	.	.	.	.

Table A-4, cont'd.

Stand Number	12	14	21	39	42	54	59	24	32	6	13	61
Linnaea borealis	.	+ 2.0	.	.	.	.	.	.	.	.	.	.
Lonicera dioica	1.7 2.0	.	.	.	.	.	.	.	*	.	.	.
Prunus virginiana	4.1 28.	.	.	+ 6.0	16. 68.	9.8 30.	.	0.7 8.0	.	.	8.1 40.	.
Quercus macrocarpa	.	.	.	.	.	0.6	.	.	.	.	.	.
Ribes missouriense	.	.	.	*	+ 2.0	.	.	.	.	.	.	.
Ribes odoratum	.	.	.	.	.	.	.	.	*	.	.	.
Rhus aromatica	.	.	.	*	.	.	.	.	.	.	.	.
Rosa acicularis	.	.	.	.	.	.	+ 2.0	.	.	1.5 30.	+ 2.0	0.8 2.0
Rosa woodsii	1.1 14.	4.5 60.	*	.	+ 2.0	+ 2.0	.	+ 8.0	.	.	.	.
Rubus parviflorus	.	.	.	.	.	.	1.9 16.	.	.	.	.	.
Shepherdia canadensis	.	.	*	+ 2.0	2.5 4.0	.	.	0.8 2.0	.	1.2 4.0	.	.
Spiraea betulifolia	2.1 22.	2.3 30.	.	.	.	8.5 72.	.	3.3 42.	+ 4.0	1.0 18.	7.6 56.	.

Table A-4, cont'd.

Stand Number	12	14	21	39	42	54	59	24	32	6	13	61
Symphoricarpos albus	4.2/58.	4.6/64.	2.9/56.	4.9/66.	11./70.	*	13./58.	+/8.0	+/8.0	7.5/64.	2.0/28.	7.4/46.
Symphoricarpos occidentalis	.	+/2.0	.	.	.	.	.	.	.	.	.	.
Toxicodendron rydbergii	*	.	.	7.2/38.	.	1.1/4.0	.	.	.	.	.	.
FORBS												
Achillea millefolium	+/12.	+/18.	+/8.0	+/8.0	.	*	1.2/10.	*	+/12.	2.2/30.	1.0/28.	2.6/24.
Agoseris glauca	.	.	.	.	.	*	.	.	.	.	.	.
Allium canadense	.	.	+/2.0	.	.	.	.	.	.	.	.	.
Amorpha canescens	.	.	.	1.7/18.	.	.	.	.	.	.	.	.
Amorpha nana	.	.	.	.	.	.	.	+/4.0	.	.	.	.
Anaphalis margaritacea	.	.	.	.	.	+/2.0	.	.	.	.	.	.
Androsace septentrionalis	.	.	.	.	.	.	+/4.0	.	.	.	.	.
Anemone patens	+/4.0	.	+/2.0	0.8/10.	+/2.0	.	+/2.0	.	.	.	.	+/6.0

Table A-4, cont'd.

Stand Number	12	14	21	39	42	54	59	24	32	6	13	61
Antennaria neglecta	.	.	+ / 10.	.	.	.	.	.	.	+ / 12.	.	.
Antennaria plantaginifolia	+ / 2.0	.	+ / 10.	+ / 2.0	.	+ / 4.0	1.8 / 8.0	+ / 8.0	4.3 / 44.	.	+ / 4.0	0.7 / 6.0
Apocynum androsaemifolium	*	.	.	.	+ / 4.0	3.2 / 22.	.	1.3 / 14.	*	.	.	.
Aralia nudicaulis	*	.	.	.	.	.	.	3.5 / 24.	*	.	.	.
Arenaria lateriflora	.	.	.	.	.	.	+ / 4.0	.	.	.	.	.
Arnica lonchophylla	.	.	.	.	.	.	.	.	+ / 8.0	.	.	.
Artemisia ludoviciana	+ / 2.0	.	.	.	.	.	.	.	.	+ / 4.0	.	1.8 / 16.
Aster ciliolatus	+ / 8.0	.	.	.	.	.	+ / 6.0	+ / 6.0	+ / 8.0	+ / 16.	0.7 / 6.0	1.5 / 12.
Astragalus alpinus	.	.	+ / 4.0	.	.	.	1.6 / 4.0	.	.	.	.	.
Astragalus sp.	.	1.8 / 30.	.	.	.	.	.	.	.	+ / 4.0	.	.
Balsamorhiza sagittata	1.1 / 6.0	.	.	.	.	.	.	.	.	.	7.3 / 40.	12. / 60.
Besseya wyomingensis	.	.	.	.	.	.	2.2 / 18.	.	.	.	.	.
Campanula rotundifolia	.	+ / 6.0	+ / 2.0	+ / 4.0	.	+ / 6.0	1.1 / 4.0	.	+ / 2.0	.	.	.

Table A-4, cont'd.

Stand Number	12	14	21	39	42	54	59	24	32	6	13	61
Cerastium arvense	+ / 2.0	.	.	.	.	.	.	.	.	.	*	.
Cirsium sp.	.	.	.	.	.	+ / 2.0	*	.	.	+ / 2.0	.	.
Corallorhiza maculata	.	.	.	.	.	.	.	.	*	.	.	.
Disporum trachycarpum	*	.	.	.	.	.	.	.	.	.	+ / 2.0	.
Delphinium nuttallianum	.	.	.	.	.	.	.	.	.	.	+ / 2.0	.
Dodecatheon pauciflorum	.	.	+ / 8.0	.	.	.	+ / 2.0	.	.	.	.	.
Erigeron speciosus	.	.	.	1.0 / 20.	.	.	.	.	.	.	.	.
Fragaria virginiana	+ / 4.0	0.7 / 62.	.	+ / 4.0	.	.	12. / 56.	.	.	0.7 / 10.	1.0 / 18.	.
Galium boreale	.	3.0 / 52.	+ / 2.0	.	2.1 / 42.	.	2.1 / 34.	+ / 2.0	.	0.8 / 14.	.	1.9 / 18.
Galium obtusum	+ / 8.0	.	.	.	.	.	.	.	.	.	1.0 / 28.	.
Geum triflorum	.	.	*	*	.	.	1.3 / 12.	.	.	.	.	.

Table A-4, cont'd.

Stand Number	12	14	21	39	42	54	59	24	32	6	13	61
Goodyera repens	.	.	.	.	.	.	.	.	+ / 4.0	.	.	.
Halenia deflexa	.	.	.	.	.	.	.	.	*	.	.	.
Hedysarum alpinum	.	2.4 / 24.	*	.	.	.	.	.	.	.	.	.
Heuchera richardsonii	.	.	*	.	.	.	+ / 2.0	+ / 14.	+ / 8.0	.	.	.
Hymenoxys acaulis	.	.	.	+ / 2.0	.	.	.	.	.	.	.	.
Lathyrus ochroleucus	+ / 2.0	6.8 / 58.	.	+ / 2.0	.	.	.	.	.	2.6 / 44.	.	+ / 6.0
Lucocrinum montanum	.	+ / 6.0	.	.	.	.	.	.	.	.	.	.
Lilium philadelphicum	.	+ / 2.0	.	.	.	.	.	.	.	.	.	.
Lupinus argenteus	.	.	.	.	.	.	.	.	.	.	6.2 / 52.	.
Maianthemum canadense	.	.	.	.	.	.	.	.	*	.	.	.

Table A-4, cont'd.

Stand Number	12	14	21	39	42	54	59	24	32	6	13	61
Melilotus albus	.	.	.	.	.	.	.	.	.	5.8 / 52.	.	.
Monarda fistulosa	.	.	.	+ / 4.0	+ / 2.0	.	.	.	.	+ / 16.	.	.
Mosses and Lichens	.	.	.	1.5 / 12.	3.4 / 16.	*	.	.	0.8 / 10.	.	.	.
Oxytropis campestris	.	+ / 4.0	*	.	.	.	.	.	.	.	.	.
Potentilla fissa	.	.	+ / 2.0	.	.	.	+ / 2.0	.	.	.	.	.
Potentilla gracilis	.	.	.	.	.	.	+ / 2.0	.	.	.	.	.
Psoralea esculenta	.	.	.	.	.	.	.	.	.	.	.	+ / 2.0
Pterospora andromedea	.	.	+ / 2.0	.	.	.	.	*	*	.	.	.
Sanicula marilandica	.	.	.	.	.	.	.	.	.	+ / 4.0	.	.
Senecio canus	.	.	.	+ / 8.0	+ / 6.0	.	.	.	.	.	.	.
Senecio plattensis	.	+ / 8.0	.	.	.	.	.	.	.	.	.	.
Smilacina racemosa	0.7 / 16.	.	.	+ / 12.	.	.	.	.	.	.	.	.

Table A-4, cont'd.

Stand Number	12	14	21	39	42	54	59	24	32	6	13	61
Smilacina stellata	.	.	.	.	.	.	1.1 / 22.	+ / 2.0	.	+ / 4.0	.	.
Solidago sp.	.	.	.	.	.	3.7 / 30.	.	.	.	.	.	.
Solidago speciosa	.	.	.	.	.	+ / 6.0	.	.	.	.	.	.
Taraxacum officinale	.	+ / 4.0	.	+ / 2.0	.	.	+ / 2.0	.	.	.	.	.
Thalictrum dioicum	.	+ / 6.0	.	+ / 2.0	.	.	.	.	.	+ / 4.0	.	.
Tragopogon dubius	.	.	.	+ / 2.0	.	.	.	.	.	.	.	.
Vicia americana	*	1.0 / 10.	.	.	*	.	.	.	+ / 2.0	1.2 / 10.	1.0 / 8.0	0.9 / 6.0
Viola adunca	.	0.7 / 8.0	.	.	.	.	+ / 8.0	.	.	0.8 / 10.	+ / 8.0	.
Woodsia oregana	.	.	.	.	.	.	.	.	*	.	.	.
Zigadenus elegans	.	.	*	.	.	.	.	.	+ / 8.0	.	.	.
Zizia aptera	*	0.9 / 38.	*	.	.	.	.	.	+ / 6.0	+ / 8.0	.	.

Table A-4, cont'd.

Stand Number	12	14	21	39	42	54	59	24	32	6	13	61
GRAMINOIDS												
Agropyron caninum	.	.	.	2.4 / 18.	1.9 / 6.0	.	.	.	.	.	.	.
Agropyron smithii	.	.	*	.		.	.	.	.	.	.	4.5 / 32.
Andropogon gerardi	.	.	.	.	.	10. / 34.	.	.	.	.	.	.
Bromus ciliatus	.	.	.	.	*	.	.	.	.	.	.	.
Bromus inermis	.	.	.	.	.	.	.	.	+ / 4.0	.	.	.
Bromus porteri	.	.	.	0.8 / 12.	.	.	.	.	.	.	.	.
Bromus pubescens	.	.	.	.	.	.	.	.	.	.	.	+ / 2.0
Carex foenea	.	3.4 / 54.	.	5.0 / 26.	.	*	.	.	2.4 / 24.	5.0 / 36.	.	.
Carex heliophila	.	.	.	.	.	.	.	.	.	.	.	12. / 56.
Carex peckii	.	.	.	.	.	.	.	.	.	.	1.3 / 22.	.
Carex richardsonii	.	+ / 2.0	*	.	.	.	.	1.1 / 12.	.	.	.	.
Carex sprengelii	.	.	.	.	.	.	+ / 2.0	.	.	.	.	.

Table A-4, cont'd.

Stand Number	12	14	21	39	42	54	59	24	32	6	13	61
Carex xerantica	.	.	.	.	.	.	2.6 / 36.	.	.	.	.	.
Danthonia spicata	.	.	.	.	.	3.0 / 1.4	.	1.1 / 14.	+ / 2.0	.	.	.
Elymus canadensis	.	.	.	.	.	*	.	.	.	.	.	.
Elymus interruptus	.	.	.	*	.	.	.	.	.	.	.	.
Elymus virginicus	.	.	.	.	.	.	.	+ / 4.0	.	.	.	.
Festuca idahoensis	.	.	.	.	.	.	.	.	.	.	.	2.6 / 10.
Festuca ovina	.	.	0.8 / 30.	0.6 / 4.0	.	.	.	.	+ / 4.0	.	.	.
Koeleria pyramidata	.	2.6 / 52.	*	.	.	.	.	+ / 4.0	2.1 / 14.	.	.	.
Oryzopsis asperifolia	0.9 / 18.	3.9 / 58.	.	.	.	.	+ / 2.0	10. / 74.	5.6 / 34.	7.5 / 58.	.	.
Oryzopsis hymenoides	.	.	+ / 4.0	.	.	.	.	.	0.7 / 8.0	.	.	.
Oryzopsis micrantha	2.6 / 52.	*	.	4.8 / 36.	.	.	.	.	.	.	.	.
Poa interior	.	.	.	.	.	.	1.8 / 14.	.	.	.	.	.

Table A-4, cont'd.

Stand Number	12	14	21	39	42	54	59	24	32	6	13	61
Poa pratensis	+/8.0	+/2.0	+/10.	.	.	*	12./76.	.	0.7/6.0	3.1/34.	.	.
Schizachne purpurascens	.	+/10.	.	.	.	.	.	+/2.0	0.9/8.0	+/8.0	.	.
Stipa occidentalis	.	.	.	.	.	.	.	.	.	.	.	4.6/28.
Species in microplots	22	28	17	28	14	18	28	21	23	28	19	20
Coverage of shrubs	18	15	10	16	45	33	17	9	1	27	26	13
Coverage of forbs	4	19	2	7	6	8	26	6	7	16	19	22
Coverage of graminoids	4	10	1	14	2	13	17	13	13	16	1	24
Total Coverage	26	44	13	37	53	54	60	28	21	59	46	59

Table A-5. Coverage (C) and frequency (F) of undergrowth species in stands of Pinus ponderosa / Quercus macrocarpa habitat type. Coverage of less than 0.5% is indicated by +. Species present in the macroplot but absent from the microplots are indicated by *. Stand numbers, locations, and topographic positions are also given.

Stand Number	28	27	44	68
Location				
Quarter	NW	SE	SW	NE
Section	30	20	33	28
Township	53N	53N	52N	5N
Range	63W	63W	60W	5E
Topographic Position				
Slope, degrees	19	21	6	29
Aspect, degrees	264	135	306	0
Elevation, m	1448	1615	1503	1256
Coverage, % / Frequency, %	C / F	C / F	C / F	C / F
SHRUBS				
Amelanchier alnifolia	1.9 / 18.	3.7 / 32.	8.5 / 48.	.
Amelanchier humulis	.	.	.	5.2 / 28.
Arctostaphylos uva-ursi	.	1.5 / 10.	.	.
Berberis repens	10. / 84.	0.8 / 12.	5.1 / 5.0	14. / 58.
Crataegus succulenta	+ / 2.0	*	.	.
Juniperus communis	0.6 / 4.0	.	.	.
Ostrya virginiana	.	.	.	1.3 / 4.0
Prunus virginiana	7.5 / 30.	+ / 4.0	.	45. / 92.
Prunus americana	.	.	5.9 / 40.	.
Quercus macrocarpa	20. / 48.	20. / 46.	26. / 50.	4.0 / 14.
Ribes missouriense	+ / 4.0	.	.	.

Table A-5, cont'd.

Stand Number	28	27	44	68
Rosa aciculari	1.4/18.	*	1.0/10.	*
Shepherdia canadensis	*	.	.	.
Spiraea betulifolia	0.6/14.	6.6/64.	20./84.	7.2/38.
Symphoricarpos albus	3.8/52.	.	.	1.6/16.
Symphoricarpos occidentalis	.	2.0/40.	4.3/34.	.
Toxicodendron rydbergii	.	.	.	7.5/34.
FORBS				
Achillea millefolium	+/2.0	*	.	.
Amorpha canescens	.	.	.	1.4/10.
Antennaria neglecta	.	.	.	*
Antennaria plantaginifolia	*	*	.	*
Apocynum androsaemifolium	.	1.1/14.	+/2.0	+/2.0
Artemisia ludoviciana	.	+/8.0	.	.
Aster ciliolatus	1.4/16.	1.0/10.	.	+/2.0
Campanula rotundifolia	.	+/2.0	+/2.0	*
Cerastium arvense	.	+/2.0	.	.
Collomia linearis	.	+/10.	.	.

Table A-5, cont'd.

Stand Number	28	27	44	68
Disporum trachycarpum	.	.	.	0.8/4.0
Erigeron subtrinervis	.	.	.	0.8/2.0
Galium boreale	1.1/22.	0.9/34.	2.2/36.	.
Hedysarum alpinum	*	.	.	.
Heuchera richardsonii	*	.	.	.
Lathyrus ochroleucus	.	+/2.0	1.2/18.	.
Lupinus argenteus	*	3.4/20.	+/2.0	.
Monarda fistulosa	+/2.0	.	+/4.0	*
Mosses and Lichens	.	.	1.3/12.	.
Petalostemon candidum	.	.	.	*
Pterospora andromedea	.	.	.	*
Sanicula marilandica	1.1/12.	.	.	.
Smilacina racemosa	.	*	.	.
Smilacina stellata	0.7/16.	.	1.8/30.	1.5/20.
Smilax herbacea	0.4/4.0	+/2.0	.	.
Taraxacum officinale	*	.	.	.
Thalictrum dioicum	1.9/18.	.	0.9/8.0	.

Table A-5, cont'd.

Stand Number	28	27	44	68
Vicia americana	0.6 / 4.0	*	+ / 2.0	.
Viola canadensis	2.6 / 24.	.	.	.
GRAMINOIDS				
Agropyron caninum	*	+ / 6.0	3.3 / 22.	.
Bromus pubescens	*	.	.	.
Carex foenea	1.1 / 34.	0.6 / 24.	9.0 / 42.	0.6 / 4.0
Carex microptera	.	.	.	1.6 / 10.
Carex torreyi	+ / 14.	.	.	.
Danthonia spicata	.	1.0 / 20.	1.8 / 6.0	*
Elymus canadensis	.	.	.	1.6 / 16.
Elymus virginicus	+ / 6.0	*	.	.
Oryzopsis asperifolia	1.0 / 20.	.	11. / 48.	1.6 / 4.0
Poa interior	+ / 4.0	+ / 16.	.	.
Poa palustris	+ / 4.0	.	.	*
Poa pratensis	.	.	4.0 / 8.0	.
Schizachne purpurascens	+ / 4.0	.	.	.
Stipa occidentalis	*	.	.	+ / 2.0

Table A-5, cont'd.

Stand Number	28	27	44	68
Species in microplots	27	21	22	19
Coverage of shrubs	46	35	71	86
Coverage of forbs	10	8	8	5
Coverage of graminoids	3	2	29	6
Total coverage	59	45	108	97

Table A-6. Coverage (C) and frequency (F) of undergrowth species in stands of *Pinus ponderosa* / *Physocarpus monogynus*, *Pinus ponderosa* / *Carex heliophila*, and *Pinus ponderosa* / *Juniperus scopulorum* habitat types. Coverage of less than 0.5% is indicated by +. Species present in the macroplot but absent from the microplots are indicated by *. Stand numbers, locations, and topographic positions are also given.

	Pinus / Physocarpus			Pinus / Carex			Pinus / Juniperus
Stand Number	57	64	65	49	23	63	58
Location							
Quarter	SW	SE	SW	NE	SE	NW	SW
Section	2	4	33	11	31	8	1
Township	4S	3S	2S	55N	3S	5S	6S
Range	2E	1E	1E	63W	5E	1E	1E
Topographic position							
Slope, degrees	33	23	25	17	5	--	24
Aspect, degrees	326	0	334	264	226	--	340
Elevation, m	1737	1567	1585	1372	1576	1431	1189
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F
SHRUBS							
Amelanchier alnifolia	2.4/2.0	.	+/2.0	3.0/30.	.	.	.
Amelanchier humulis	.	+/2.0	1.8/8.0	.	.	.	.
Artemisia frigida	.	.	.	*	.	.	+/4.0
Berberis repens	.	+/4.0	14./66.	11./62.	.	.	.
Cercocarpus montanus	.	+/2.0	.	.	.	.	.
Juniperus communis	.	+/2.0	11./24.	*	.	.	.
Juniperus scopulorum	.	.	.	.	.	.	5.6/16.

Table A-6, cont'd.

Stand Number	57	64	65	49	23	63	58
Physocarpus monogynus	23. / 66.	73. / 100	29. / 82.	.	.	.	.
Prunus virginiana	0.7 / 8.0	0.8 / 2.0	8.6 / 38.	*	.	.	.
Quercus macrocarpa	.	.	.	1.2 / 2.0	.	.	.
Rhus aromatica	.	.	.	.	.	.	*
Ribes cereum	.	.	.	.	.	*	*
Ribes odoratum	*	.	.	.	.	.	.
Ribes setosum	.	.	+ / 2.0	.	.	.	.
Rosa acicularis	2.0 / 16.	+ / 2.0	3.2 / 28.	.	.	.	.
Rosa woodsii	.	.	+ / 2.0	.	.	.	.
Shepherdia canadensis	3.1 / 8.0	.	.	0.6 / 14.	.	.	.
Spiraea betulifolia	.	*	.	3.5 / 26.	.	.	.
Symphoricarpos albus	9.7 / 64.	1.1 / 14.	16. / 74.	0.5 / 10.	.	.	.
FORBS							
Achillea millefolium	.	.	.	0.8 / 10.	.	.	.
Agoseris glauca	.	.	.	.	.	.	+ / 4.0
Anemone patens	0.8 / 14.	+ / 2.0	.	.	+ / 2.0	.	6.4 / 48.
Antennaria parvifolia	1.6 / 16.	.	.	.	.	.	.

Table A-6, cont'd.

Stand Number	57	64	65	49	23	63	58
Antennaria plantaginifolia	.	*	*	.	0.7/8.0	+/2.0	*
Antennaria neglecta	.	.	.	0.8/10.	.	.	.
Apocynum androsaemifolium	+/2.0	.	.	*	.	.	.
Artemisia ludoviciana	.	.	.	.	1.4/16.	+/2.0	.
Aster ciliolatus	1.0/8.0	.	.	.	2.5/40.	.	5.6/16.0
Aster ericoides	.	.	.	.	*	.	.
Astragalus alpinum	0.8/14.	.	.	*	*	.	.
Campanula rotundifolia	.	.	.	.	+/2.0	+/2.0	1.2/18.
Cerastium arvense	.	.	.	+/6.0	*	.	.
Corallorhiza maculata	.	.	.	.	+/2.0	.	.
Disporum trachycarpum	+/4.0	+/2.0	.	.	.	.	.
Erigeron glabellus	.	.	.	.	*	.	.
Fragaria vesca	.	.	*	.	.	.	.
Fragaria virginiana	+/6.0	.	.	1.3/12.	.	.	.
Galium boreale	3.8/52.	+/4.0	.	.	*	.	.
Hedeoma hispida	.	.	.	.	.	.	*

Table A-6, cont'd.

Stand Number	57	64	65	49	23	63	58
Hedysarum alpinum	.	.	*	.	.	.	.
Heuchera richardsonii	0.6/4.0	.	*	.	.	.	.
Hieracium umbellatum	.	.	.	.	.	+/2.0	.
Liatrus punctata	.	.	.	.	.	+/2.0	.
Mertensia lanceolata	.	.	.	.	*	.	.
Mosses & Lichens	12./58.	4.3/28.	71./42.	4.0/10.	.	.	0.5/8.0
Polygala alba	.	.	.	.	.	.	+/4.0
Potentilla hippiana	.	.	.	.	+/2.0	.	.
Psoralea argophylla	.	.	.	.	.	+/2.0	
Senecio integerrimus	.	.	+/2.0	.	.	.	.
Smilacina racemosa	.	.	.	.	*	.	.
Smilacina stellata	+/2.0	.	.	.	+/4.0	.	.
Solidago speciosa	5.6/30.	.	.	+/2.0	.	.	.
Thermopsis rhombifolia	.	.	.	+/2.0	.	.	.
Viola adunca	+/6.0	.	+/2.0	.	.	.	.
Zigadenus elegans	.	+/4.0	.	.	.	+/2.0	.
Zizia aptera	1.1/14.	.	.	.	.	.	.

Table A-6, cont'd.

Stand Number	57	64	65	49	23	63	58
GRAMINOIDS							
Agropyron caninum	3.2/30.	+/2.0	*	+/2.0	.	.	.
Agropyron smithii	.	.	.	.	.	.	+/2.0
Andropogon scoparius	.	.	.	.	.	.	*
Bouteloua curtipendula	.	.	.	.	.	.	1.4/8.0
Bromus inermis	.	.	.	.	.	.	.
Carex filifolia	.	.	.	.	.	.	+/8.0
Carex foenea	.	.	.	11./60.	.	.	.
Carex heliophila	.	.	.	40./66.	23./100.	48./98.	+/4.0
Danthonia spicata	.	.	.	5.2/24.	7.8/38.	.	.
Festuca idahoensis	*	.	.	.	.	.	.
Koeleria pyramidata	.	.	.	.	.	.	*
Oryzopsis hymenoides	*	.	.	.	.	.	*
Oryzopsis micrantha	.	.	.	1.3/4.0	.	.	1.1/60.
Poa pratensis	.	.	.	*	10./66.	+/6.0	.
Schizachne purpurascens	.	+/2.0	.	.	.	.	.

Table A-6, cont'd.

Stand Number	57	64	65	49	23	63	58
Sitanion hystrix	.	.	.	.	.	.	*
Stipa occidentalis	.	+/2.0	.	*	*	.	.
Species in microplots	21	16	13	18	11	9	13
Coverage of shrubs	41	76	84	20	--	--	6
Coverage of forbs	28	5	71[a]	8	5	1	14
Coverage of graminoids	3	1	--	58	41	48	3
Total coverage	72	82	155	86	47	49	23

[a]Mosses and lichens provide 71% of the coverage in this stand.

Table A-7. Coverage (C) and frequency (F) of undergrowth species in stands of *Pinus ponderosa* / *Arctostaphylos uva-ursi* habitat type. Coverage of less than 0.5% is indicated by +. Species present in the macroplot but absent from the microplots are indicated by *. Stand numbers, locations, and topographic positions are also given.

Stand Number	16	17	18	19	34	37	41	62	66	70
Location										
Quarter	NE	SW	NW	NE	SW	SW	SE	SE	SE	NW
Section	10	34	33	4	1	23	25	12	13	29
Township	3N	3N	3N	3N	4S	1S	2S	2S	2S	1S
Range	4E	4E	4E	4E	2E	1E	1E	5E	5E	4E
Topographic Position										
Slope, degrees	3	6	16	10	21	--	3	10	20	20
Aspect, degrees	10	282	48	46	320	--	242	30	56	172
Elevation, m	1638	1577	1634	1676	1623	2042	1913	1573	1548	1939
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
SHRUBS										
Amelanchier alnifolia	1.2/16.	.	0.9/18.	+/2.0	1.8/22.	.	2.0/40.	.	.	.
Amelanchier humulis	.	.	.	.	.	.	.	.	+/2.0	0.7/8.0
Arctostaphylos uva-ursi	10./64.	25./88.	13./60.	21./84.	9.5/68.	18./80.	29./56.	76./100.	85./100.	42./74.
Berberis repens	.	.	8.1/68.	+/2.0	.	9.6/76.	.	.	.	.
Juniperus communis	.	*	+/2.0	*	1.1/4.0	2.9/10.	.	.	.	+/2.0
Physocarpus monogynus	.	.	.	.	4.2/38.	.	.	.	.	.

Table A-7, cont'd.

Stand Number	16	17	18	19	34	37	41	62	66	70
Prunus pensylvanica	.	.	.	.	.	.	.	.	.	+ / 2.0
Prunus virginiana	*	.	.	.	0.9 / 6.0	.	.	.	+ / 2.0	.
Pyrola sp.	.	.	*	.	.	.	.	.	.	.
Ribes missouriense	.	.	.	.	.	.	.	.	+ / 2.0	.
Rosa acicularis	0.9 / 16.	*	.	0.9 / 14.	.	+ / 10.	0.7 / 18.	1.0 / 10.	+ / 2.0	.
Rosa woodsii	.	.	.	.	.	.	.	+ / 2.0	.	+ / 2.0
Rubus idaeus	.	.	.	.	.	.	.	.	1.4 / 8.0	.
Shepherdia canadensis	1.1 / 6.0	+ / 2.0	9.0 / 28.	9.0 / 44.	+ / 2.0	.	.	.	.	.
Spiraea betulifolia	3.3 / 26.	2.0 / 28.	1.4 / 24.	2.8 / 44.	.	.	0.7 / 16.	3.4 / 26.	3.3 / 42.	.
Symphoricarpos albus	3.5 / 42.	+ / 2.0	0.9 / 14.	+ / 4.0	2.7 / 46.	2.1 / 42.	5.5 / 62.	3.0 / 32.	4.9 / 32.	11. / 70.
FORBS										
Achillea millefolium	*	+ / 4.0	+ / 2.0	+ / 2.0	*	3.5 / 40.	0.9 / 14.	+ / 4.0	+ / 2.0	+ / 4.0
Agoseris glauca	.	.	.	.	.	.	.	.	+ / 2.0	.
Androsace septentrionalis	.	.	*	.	.	.	.	.	.	.

Table A-7, cont'd.

Stand Number	16	17	18	19	34	37	41	62	66	70
Anemone canadensis	.	.	.	.	.	.	.	.	.	+ / 4.0
Anemone multifida	.	.	+ / 6.0	.	+ / 2.0	.	.	.	.	.
Anemone patens	*	.	.	.	.	+ / 4.0	+ / 8.0	+ / 2.0	.	.
Antennaria neglecta	*	0.6 / 12.	+ / 4.0	.	+ / 2.0	.	+ / 6.0	.	.	.
Antennaria plantaginifolia	.	.	.	.	.	2.9 / 10.	.	.	.	.
Apocynum androsaemifolium	+ / 2.0	+ / 6.0	*	*	.	.	.	+ / 2.0	+ / 2.0	.
Artemisia ludoviciana	.	.	.	.	.	+ / 4.0	+ / 1.0	0.6 / 4.0	.	+ / 2.0
Arnica sp.	.	.	.	.	*	.	.	.	.	.
Aster ciliolatus	+ / 4.0	+ / 8.0	+ / 2.0	.	.	+ / 6.0	.	1.7 / 8.0	.	.
Astragalus alpinus	*	*	.	*	.	.	.	.	.	.
Astragalus miser	.	.	.	.	.	.	+ / 6.0	.	.	.
Astragalus sp.	.	.	.	.	.	2.1 / 14.	.	.	.	.
Balsamorhiza sagittata	.	.	.	.	.	.	4.6 / 22.	.	.	.

Table A-7, cont'd.

Stand Number	16	17	18	19	34	37	41	62	66	70
Campanula rotundifolia	*	*	.	+/4.0	.	.	.	+/2.0	+/2.0	1.3/12.
Castilleja sulphurea	.	.	.	.	.	1.1/6.0	+/2.0	.	.	.
Cirsium ochrocentrum	.	.	.	.	.	.	.	.	+/2.0	.
Corallorhiza maculata	*	*	+/2.0	.	.	.	.	.	.	0.5/2.0
Fragaria virginiana	.	+/6.0	+/6.0	+/6.0	+/2.0	2.6/34.	0.8/20.	+/2.0	0.7/8.0	.
Galium boreale	.	.	.	.	+/10.	+/18.	1.1/22.	.	.	.
Geum triflorum	.	.	.	.	0.6/14.	.	.	.	.	.
Glycyrrhiza lepidota	.	.	.	.	.	.	.	6.4/36.	.	.
Halenia deflexa	.	.	.	.	.	+/4.0	.	.	.	.
Hedysarum alpinum	*	*	*	+/2.0	1.4/8.0	4.6/36.	.	.	.	.
Heuchera richardsonii	.	.	+/2.0	.	+/2.0	.	.	.	+/2.0	.
Hieracium albiflorum	.	.	.	.	.	.	.	.	+/2.0	.

Table A-7, cont'd.

Stand Number	16	17	18	19	34	37	41	62	66	70
Lathyrus ochroleucus	+/4.0	0.8/10.	+/2.0	5.7/50.	.	2.6/44.	0.7/16.	12./68.	+/2.0	.
Lupinus argenteus	.	.	.	.	.	4.0/42.	0.7/16.	.	.	.
Monarda fistulosa	.	.	.	.	+/2.0	.	.	.	+/2.0	.
Mosses and Lichens	.	.	.	.	+/2.0	0.6/4.0	0.9/8.0	.	.	.
Oxytropis campestris	.	*	.	*	.	.	.	.	.	.
Oxytropis lambertii	.	.	.	.	.	.	0.4/6.0	.	.	.
Potentilla fissa	.	.	.	.	.	.	.	.	1.6/16.	0.7/8.0
Psoralea argophylla	.	.	.	.	.	.	.	.	.	+/2.0
Pterospora andromedea	.	.	*	*	.	.	.	.	+/2.0	.
Senecio plattensis	.	.	.	.	+/4.0	.	.	.	.	.
Senecio pseudoaureus	.	.	.	.	.	.	+/10.	.	.	.
Smilacina stellata	.	.	.	.	.	.	.	1.3/20.	+/2.0	+/2.0

Table A-7, cont'd.

Stand Number	16	17	18	19	34	37	41	62	66	70
Solidago speciosa	+ / 4.0	+ / 12.	.	+ / 12.	.	.	.	+ / 2.0	.	+ / 8.0
Swertia radiata	.	.	.	.	+ / 6.0	.	.	.	.	.
Sysyrinchium angustifolium	.	.	.	.	.	+ / 2.0	.	.	.	.
Thelypodium integrifolium	.	.	.	.	*	.	.	.	.	.
Thermopsis rhombifolia	.	.	.	.	.	.	*	.	3.4 / 20.	.
Vicia americana	.	.	0.9 / 8.0	0.7 / 6.0	+ / 2.0	+ / 8.0	.	1.2 / 10.	.	.
Viola adunca	+ / 8.0	+ / 2.0	+ / 6.0	+ / 8.0	.	+ / 10.	.	.	.	.
Woodsia oregana	.	.	.	.	.	.	.	.	.	+ / 2.0
Zigadenus elegans	.	.	.	.	+ / 8.0	.	.	.	.	.
Zizia aptera	.	.	.	*	+ / 12.	.	.	.	.	.
GRAMINOIDS										
Agropyron caninum	.	.	.	.	.	.	.	.	+ / 2.0	.

Table A-7, cont'd.

Stand Number	16	17	18	19	34	37	41	62	66	70
Agropyron sp.	.	.	.	.	.	.	*	.	.	.
Bromus ciliatus	.	.	.	.	.	.	2.3/14.	.	.	.
Bromus inermis	.	.	.	.	.	0.9/6.0	.	+/4.0	.	.
Bromus porteri	.	.	.	.	+/2.0	.	+/4.0	.	.	.
Carex foenea	.	.	.	.	.	6.9/40.	.	.	.	17./68.
Carex heliophilia	.	.	+/2.0	*	.	.	9.6/50.	.	.	.
Danthonia intermedia	.	.	.	.	.	8.9/46.	.	.	.	.
Danthonia spicata	2.1/4.0	1.4/26.	+/4.0	.	.	.	1.7/8.0	.	1.1/4.0	+/2.0
Festuca ovina	.	.	*	.	+/2.0	0.9/8.0	.	.	.	.
Koeleria pyramidata	.	.	.	.	+/8.0	2.0/12.	.	.	.	.
Oryzopsis asperifolia	+/4.0	1.0/10.	5.2/64.	+/2.0	.	11./36.	.	8.8/40.	14./48.	+/2.0
Oryzopsis micrantha	.	.	.	*	.	.	.	.	.	.
Oryzopsis pungens	.	*	+/2.0	.	.	.	.	.	.	.

Table A-7, cont'd.

Stand Number	16	17	18	19	34	37	41	62	66	70
Panicum Leibergii	.	.	.	.	.	.	.	.	.	0.8/8.0
Stipa occidentalis	.	.	.	.	.	1.8/12.	.	.	.	.
Stipa richardsonii	.	.	.	.	.	.	2.4/16.	.	.	+/4.0
Specis in microplots	13	14	21	16	24	29	24	19	25	21
Coverage of shrubs	20	27	34	34	20	33	38	84	95	54
Coverage of forbs \	1	3	3	8	4	26	11	24	8	4
Coverage of graminoids	2	2	6	--	1	32	16	9	15	18
Total Coverage	23	32	42	42	25	91	65	117	118	76

Table A-8. Coverage (C) and frequency (F) of undergrowth species in stands of *Pinus ponderosa* / *Juniperus communis* habitat type. Coverage of less than 0.5% is indicated by +. Species present in the macroplot but absent from the microplots are indicated by *. Stands numbers, locations, and topographic positions are also given.

Stand Number	1	5	7	8	29	38	53
Location							
Quarter	SW	SW	SW	NW	SW	SE	NW
Section	33	14	14	11	8	17	32
Township	3E	4E	4E	1E	3E	1E	60W
Range	2S	4N	4N	4N	3S	1N	51N
Topographic position							
Slope, degrees	12	17	12	32	--	5	14
Aspect, degrees	328	186	232	276	--	226	306
Elevation, m	1394	1554	1554	1737	1645	1989	1859
Coverage, % / Frequency, %	C / F	C / F	C / F	C / F	C / F	C / F	C / F
SHRUBS							
Amelanchier alnifolia	.	1.4 / 16.	+ / 4.0	.	0.6 / 22.	.	1.3 / 14.
Arctostaphylos uva-ursi	9.1 / 48.	*	.	14. / 80.	1.9 / 10.	31. / 92.	.
Berberis repens	+ / 2.0	12. / 82.	6.2 / 42.	2.1 / 44.	*	1.7 / 28.	6.6 / 82.
Chimaphila umbellata	.	.	.	+ / 2.0	.	.	.
Juniperus communis	28. / 52.	27. / 42.	38. / 62.	20. / 62.	42. / 78.	16. / 44.	4.2 / 6.0
Prunus americana	.	.	.	.	.	.	+ / 8.0
Prunus virginiana	.	.	+ / 2.0	+ / 6.0	.	.	.
Pyrola secunda	.	.	.	0.7 / 16.	.	.	.
Ribes cereum	.	.	+ / 2.0	+ / 6.0	.	.	.
Rosa acicularis	+ / 6.0	0.6 / 24.	+ / 10.	1.3 / 20.	*	+ / 2.0	.

Table A-8, cont'd.

Stand Number	1	5	7	8	29	38	53
Shepherdia canadensis	4.5/16.	.	.	5.1/22.	0.8/2.0	.	1.3/20.
Spiraea betulifolia	.	0.6/12.	2.5/22.	3.9/48.	+/2.0	.	9.4/74.
Symphoricarpos albus	2.9/34.	19./88.	23./94.	+/8.0	1.7/38.	12./28.	.
Toxicodendron rydbergii	.	+/2.0	.	.	.	.	.
FORBS							
Achillea millefolium	.	1.1/14.	+/6.0	+/6.0	*	0.7/8.0	*
Anemone patens	.	+/4.0	+/2.0	+/14.	+/2.0	.	.
Antennaria neglecta	+/2.0	.	.	.	.	.	.
Antennaria plantaginifolia	.	+/4.0	+/6.0	.	.	.	.
Apocynum androsaemifolium	.	+/2.0	.	.	+/2.0	.	*
Artemisia ludoviciana	.	+/2.0	+/8.0	.	.	.	*
Arnica cordifolia	.	.	.	+/6.0	.	.	.
Astragalus alpinus	.	.	.	.	*	.	.
Astragalus sp.	.	+/2.0	*	.	.	.	.
Balsamorhiza sagittata	.	.	.	.	.	*	.
Campanula rotundifolia	.	.	.	.	*	+/6.0	.
Cerastium arvense	.	.	+/2.0	.	.	.	.

Table A-8, cont'd.

Stand Number	1	5	7	8	29	38	53
Clematis pseudoalpina	.	.	.	+/2.0	.	.	.
Clematis tenuiloba	0.6/24.	.	.	.	.	.	.
Fragaria virginiana	4.0/16.	+/4.0	+/6.0	0.9/26.	+/8.0	+/8.0	.
Galium boreale	.	.	.	.	+/14.	+/8.0	+/6.0
Galium obtusum	.	0.6/14.	1.3/22.	+/14.	.	.	.
Geum triflorum	+/4.0	.	.	.	.	.	.
Haplopappus armeroides	.	.	.	.	*	.	.
Hedysarum alpinum	.	.	.	.	.	1.9/12.	.
Iris missouriensis	0.7/18.	.	.	.	*	.	.
Lathyrus ochroleucus	.	.	.	0.6/12.	.	1.2/18.	.
Lupinus argenteus	.	0.7/16.	+/4.0	*	*	+/2.0	*
Melilotus albus	.	0.9/14.	1.3/12.	.	.	.	.
Musineon tenuifolium	+/4.0	.	.	.	+/2.0	.	.
Monarda fistulosa	.	.	+/2.0	.	.	.	.
Mosses & Lichens	.	.	.	.	.	.	0.9/6.0
Phlox alysifolia	+/6.0	.	.	.	.	.	.
Potentilla fruiticosa	.	.	.	*	.	.	.

Table A-8, cont'd.

Stand Number	1	5	7	8	29	38	53
Potentilla hippiana	*	.	.	.	*	.	.
Senecio sp.	.	.	*	.	.	.	.
Smilacina racemosa	.	.	*	+ / 4.0	.	.	.
Smilacina stellata	+ / 10.	.	.	.	+ / 10.	.	1.2 / 18.
Swertia radiata	.	.	.	+ / 8.0	*	.	.
Taraxacum officinale	.	+ / 6.0	+ / 2.0	.	.	.	.
Thalictrum venulosum	.	.	.	1.7 / 12.	.	.	.
Thalictrum dioicum	.	.	.	.	.	.	+ / 4.0
Thermopsis rhombifolia	.	.	*	.	.	.	.
Vicia americana	.	0.8 / 10.	*	*	*	.	.
Viola adunca	+ / 4.0	.	*	+ / 6.0	.	.	+ / 40.
Viola canadensis	.	.	.	+ / 2.0	.	.	.
Zigadenus elegans	.	.	.	0.6 / 14.	+ / 2.0	.	.
Zizia aptera	.	.	.	+ / 10.	.	.	.

Table A-8, cont'd

Stand Number	1	5	7	8	29	38	53
GRAMINOIDS							
Agropyron smithii	.	.	.	.	.	.	*
Bromus inermis	0.9/24.	0.8/32.	+/14.	1.3/30.	.	.	.
Bromus pubescens	.	.	.	.	+/6.0	.	.
Carex foenea	.	.	+/8.0	.	.	1.4/14.	5.2/18.
Carex heliophila	+/2.0	.	.	.	.	.	.
Danthonia spicata	.	.	.	.	.	2.5/14.	0.6/4.0
Oryzopsis asperifolia	.	.	.	2.6/22.	.	3.3/18.	1.3/10.
Poa interior	.	.	.	.	+/6.0	.	.
Poa pratensis	.	3.5/22.	+/10.	.	.	.	*
Stipa occidentalis	.	.	.	.	.	*	*
Species in microplots	17	22	22	27	15	15	14
Coverage of shrubs	45	61	71	48	47	61	23
Coverage of forbs	7	6	4	6	1	5	3
Coverage of graminoids	1	4	1	4	--	7	7
Total Coverage	53	71	76	58	48	73	33

Table A-9. Coverage (C) and frequency (F) of undergrowth species in stands of Populus tremuloides / Corylus cornuta habitat type, including the Pteridium aquilinum and Aralia nudicaulis phases. Coverage of less than 0.5% is indicated by +. Species present in the macroplot but absent from the microplots are indicated by *. Stand numbers, locations, and topographic positions are also given.

	Populus / Corylus ht.						Pteridium phase		Aralia phase
Stand Number	67	69	55	2	30	31	25	26	43
Location									
Quarter	NW	SW	NE	SE	NE	SE	NW	SW	SW
Section	11	30	27	34	8	31	8	5	30
Township	2S	5N	5N	1S	51N	5N	52N	52N	4N
Range	5E	1E	4E	6E	60W	1E	63W	63W	5E
Topographic Position									
Slope, degrees	--	7	9	40	7	7	--	--	12
Aspect, degrees	--	56	8	30	295	38	--	--	340
Elevation, m	1533	1902	1387	1219	1585	1874	1737	1653	1554
Coverage, % / Frequency, %	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F	C/F
SHRUBS									
Amelanchier alnifolia	0.6/4.0	2.5/6.0	+/4.0	*	13./42.	4.5/8.0	0.7/8.0	2.9/20.	1.0/8.0
Berberis repens	.	+/2.0	2.0/20.	.	5.4/44.	2.0/28.	5.7/50.	0.9/16.	1.7/16.
Corylus cornuta	87./100	43./86.	.	70./100	28./62.	73./96.	47./92.	4.7/24.	12./62.
Crataegus succulenta	.	.	.	.	1.5/4.0	.	*	+/2.0	.

Table A-9, cont'd.

Stand number	67	69	55	2	30	31	25	26	43
Lonicera dioica	3.8 32.	3.9 16.	0.7 8.0	1.4 18.	0.7 8.0	.	0.8 2.0	.	+ 6.0
Ostrya virginiana	.	.	8.9 62.	.	.	.	.	.	.
Physocarpus monogynus	*	.	.	5.4 28.	.	.	.	.	.
Prunus virginiana	+ 2.0	.	+ 10.	3.4 24.	1.7 20.	+ 4.0	1.0 4.0	.	1.3 10.
Pyrola asarifolia	15. 66.	.	+ 6.0	5.4 46.	0.9 28.	3.0 58.	.	.	.
Pyrola elliptica	.	.	0.6 12.	.	.	.	0.9 26.	+ 4.0	.
Pyrola secunda	+ 2.0	.	+ 4.0	1.2 20.	.	*	.	.	0.8 12.
Quercus macrocarpa	.	.	.	.	*	.	.	.	.
Ribes odoratum	0.7 8.0	.	+ 4.0	0.7 6.0	3.6 22.	.	*	.	+ 6.0
Rosa acicularis	+ 2.0	1.0 6.0	0.7 16.	1.1 14.	3.0 34.	.	.	7.5 62.	2.0 28.
Rubus idaeus	.	+ 2.0	+ 6.0	0.6 6.0	1.2 10.	1.1 14.	1.5 12.	+ 4.0	19. 78.
Rubus parviflorus	.	2.5 6.0	.	.	+ 2.0	*	*	*	.

Table A-9, cont'd.

Stand Number	67	69	55	2	30	31	25	26	43
Rubus pubescens	3.4 / 26.	0.5 / 8.0	1.7 / 10.	.	.	.	.	.	3.9 / 22.
Spiraea betulifolia	.	0.5 / 8.0	1.3 / 10.	2.8 / 34.	11. / 54.	+ / 10.	9.7 / 42.	2.9 / 20.	+ / 2.0
Symphoricarpos albus	0.9 / 6.0	1.8 / 12.	8.1 / 44.	2.6 / 38.	5.1 / 46.	2.9 / 36.	+ / 4.0	3.6 / 34.	4.1 / 42.
Symphoricarpos occidentalis	0.7 / 8.0	2.0 / 12.	.	.	.	.	.	.	.
Toxicodendron rydbergii	*	.	.	1.8 / 24.	+ / 2.0	.	.	.	5.6 / 44.
FORBS									
Achillea millefolium	*	.	.	*	+ / 4.0	*	*	0.6 / 12.	+ / 4.0
Actaea rubra	1.1 / 6.0	9.8 / 52.	.	1.1 / 8.0	+ / 2.0	12. / 56.	.	*	.
Adenocaulon bicolor	.	.	.	.	+ / 2.0	.	.	.	.
Agrimonia striata	.	.	.	.	.	.	.	+ / 2.0	*
Anaphalis margaritacea	.	.	.	.	.	*	0.6 / 4.0	1.4 / 16.	.
Anemone canadensis	*	+ / 2.0	.	.	.	.	.	.	.
Anemone cylindrica	.	.	.	.	.	.	.	.	+ / 6.0
Apocynum androsaemifolium	.	.	+ / 2.0	+ / 6.0	+ / 2.0	.	.	+ / 2.0	+ / 2.0

Table A-9, cont'd.

Stand Number	67	69	55	2	30	31	25	26	43
Aquilegia canadensis	.	.	.	0.7 / 8.0	.	.	.	.	.
Aralia nudicaulis	27. / 8.0	1.5 / 10.	2.3 / 14.	6.9 / 50.	2.8 / 12.	7.5 / 32.	3.0 / 12.	+ / 2.0	47. / 96.
Arnica cordifolia	.	5.0 / 50.	1.7 / 48.	.	0.9 / 28.	13. / 44.	1.1 / 6.0	2.9 / 18.	.
Artemisia ludoviciana	.	.	.	.	.	.	.	+ / 4.0	.
Aster ciliolatus	+ / 2.0	3.2 / 28.	1.4 / 24.	+ / 12.	.	7.3 / 64.	1.0 / 18.	1.7 / 18	19. / 80.
Astragalus alpinus	.	.	.	.	.	.	.	.	0.6 / 4.0
Cornus canadensis	.	.	*	.	.	.	.	.	.
Delphinium nuttallianum	.	.	.	.	.	.	*	.	.
Disporum trachycarpum	.	9.1 / 40.	0.8 / 20.	.	2.8 / 46.	9.2 / 64.	+ / 2.0	*	2.6 / 42.
Dodecatheon sp.	.	.	.	*	.	.	.	.	.
Fragaria virginiana	3.4 / 24.	1.6 / 16.	.	1.7 / 28.	0.6 / 14.	2.8 / 40.	2.0 / 20.	2.8 / 52.	1.4 / 14.
Galium boreale	*	.	.	.	+ / 4.0	.	+ / 8.0	1.7 / 38.	1.0 / 20.
Galium triflorum	1.4 / 26.	7.8 / 42.	0.8 / 8.0	+ / 10.	1.4 / 26.	0.9 / 16.	2.9 / 20.	1.4 / 16.	.

Table A-9, Cont'd.

Stand Number	67	69	55	2	30	31	25	26	43
Geranium bicknellii	.	.	+/2.0	.	.	.	.	.	.
Geranium richardsonii	2.8/22.	+/6.0	.	.	.	6.7/42.	.	1.0/10.	.
Goodyera repens	.	.	+/2.0	.	.	.	.	.	.
Habenaria viridis	.	.	.	.	.	.	+/2.0	+/2.0	+/2.0
Halenia deflexa	.	.	.	.	.	.	.	.	2.7/36.
Hedysarum alpinum	.	.	.	1.0/4.0	.	.	.	.	.
Heracleum sphondylium	*	3.6/20.	.	*	+/6.0	12./74.	2.6/24.	2.3/12.	4.0/26.
Heuchera richardsonii	.	.	.	*	.	.	*	+/2.0	.
Hieracium umbellatum	.	.	+/2.0	.	7.2/62.	.	.	.	.
Lathyrus ochroleucus	.	3.2/20.	+/2.0	+/6.0	0.7/10.	1.7/18.	+/4.0	1.9/16.	3.7/30.
Lichens & Mosses	3.3/8.0	.	2.0/12.	.	.	.	.	.	.
Linnaea borealis	.	.	2.3/12.	.	.	.	.	.	.
Lupinus argenteus	.	.	.	.	+/4.0	.	.	.	.

Table A-9, Cont'd.

Stand Number	67	69	55	2	30	31	25	26	43
Maianthemum canadense	4.6/48.	0.9/25.	2.5/70.	5.1/68.	+/10.	1.5/50.	.	.	2.0/38.
Nepeta cataria	.	.	.	+/2.0	+/2.0	.	.	.	.
Osmorhiza chilensis	*	4.9/40.	+/4.0	.	3.8/52.	15./84.	15./80.	7.5/76.	.
Osmorhiza depauperata	.	2.4/20.	.	.	.	.	.	.	.
Parthenocissus vitacea	.	.	*	.	.	.	.	.	.
Pteridium aquilinum	.	6.4/27.	3.0/14.	.	21./76.	2.4/10.	23./74.	33./96.	.
Pterospora andromedea	.	.	.	*	.	.	.	.	.
Ranunculus abortivus	.	.	.	.	.	.	+/2.0	*	.
Sanicula marilandica	0.6/12.	2.1/22.	.	+/12.	1.0/22.	1.8/20.	3.2/36.	7.2/54.	6.3/64.
Smilacina racemosa	.	.	.	+/4.0	.	.	.	.	.
Smilacina stellata	1.0/8.0	2.8/26.	+/2.0	0.7/8.0	0.7/8.0	1.1/14.	1.6/22.	1.9/24.	+/2.0
Smilax herbacea	.	.	*	.	.	.	.	.	.
Taraxacum officinale	.	+/12.	0.6/12.	.	+/12.	0.9/6.0	2.2/20.	7.3/66.	2.0/20.

Table A-9, Cont'd.

Stand Number	67	69	55	2	30	31	25	26	43
Thalictrum dasycarpum	0.8 / 10.	3.9 / 22.	1.1 / 34.	0.6 / 4.0	2.4 / 36.	6.4 / 42.	1.7 / 8.0	4.6 / 30.	+ / 4.0
Trifolium repens	.	0.5 / 12.	.	.	+ / 2.0	+ / 2.0	.	+ / 14.	.
Vicia americana	.	.	.	.	+ / 6.0	+ / 6.0	*	0.9 / 16.	1.4 / 16.
Viola adunca	.	.	.	.	+ / 10.	.	.	.	+ / 2.0
Viola canadensis	7.3 / 58.	20. / 89.	+ / 6.0	1.6 / 24.	1.0 / 2.0	15. / 86.	19. / 96.	9.8 / 68.	1.3 / 42.
Viola renifolia	.	.	.	.	.	.	.	*	.
Woodsia scopulina	.	.	.	+ / 2.0	.	.	.	.	.
Zizia aptera	.	.	.	+ / 2.0	.	.	.	.	.
GRAMINOIDS									
Agropyron repens	.	.	.	.	.	.	.	.	0.9 / 6.0
Bromus ciliatus	.	.	.	.	.	.	.	.	+ / 2.0
Calamagrostis canadensis	.	.	.	.	.	.	.	+ / 2.0	1.1 / 6.0

Table A-9, Cont'd.

Stand Number	67	69	55	2	30	31	25	26	43
Carex aurea	.	.	+ / 4.0	.	.	.	.	.	.
Carex deweyana	.	+ / 4.0	.	.	.	.	.	.	.
Carex foenea	.	.	.	.	.	.	.	1.0 / 10.	.
Carex saximontana	8.0 / 24.	.	.	2.4 / 22.	.	.	.	+ / 2.0	.
Carex sprengelii	+ / 2.0	.	.	.	+ / 2.0	.	+ / 2.0	+ / 6.0	.
Danthonia spicata	.	.	.	.	.	.	.	.	*
Elymus virginicus	4.8 / 36.	7.8 / 46.	.	.	+ / 2.0	.	3.7 / 28.	1.6 / 22.	4.0 / 28.
Festuca subulata	.	1.1 / 8.0	.	.	.	.	.	.	.
Melica subulata	.	.	.	.	1.5 / 32.	.	13. / 80.	4.7 / 62.	.
Oryzopsis asperifolia	.	2.8 / 26.	19. / 86.	3.3 / 44.	3.6 / 48.	1.8 / 24.	1.3 / 12.	+ / 2.0	14. / 58.
Phleum pratense	.	.	.	.	.	.	.	.	9.6 / 50.
Poa pratensis	.	2.2 / 16.	.	.	.	1.4 / 14.	+ / 4.0	1.0 / 30.	7.0 / 32.
Schizachne purpurascens	.	.	.	.	.	6.1 / 64.	.	.	.

Table A-9, Cont'd.

Stand Number	67	69	55	2	30	31	25	26	43
Species in microplots	26	37	35	32	44	31	33	42	41
Coverage of shrubs	113	58	25	90	75	87	68	23	51
Coverage of forbs	54	89	20	28	49	118	80	91	98
Coverage of graminoids	13	14	19	6	6	9	18	9	37
Total coverage	180	161	64	124	130	214	166	123	185

Table A-10. Coverage (C) and frequency (F) of undergrowth species in stands of *Picea glauca* / *Vaccinium scoparium* and *Picea glauca* / *Linnaea borealis* habitat types. Coverage of less than 0.5% is indicated by +. Species present in the macroplot but absent from the microplots are indicated by *. Stand numbers, locations, and topographic positions are also given.

	Picea - Vaccinium					Picea - Linnaea				
Stand Number	47	46	9	51	48	15	40	52	50	60
Location:										
Quarter	NE	NW	SE	SW	NW	NE	SW	SE	NW	SE
Section	23	12	14	26	4	11	5	28	7	21
Township	4N	4N	4N	4N	2N	1S	1N	4N	2S	1N
Range	2E	2E	1E	1E	2E	2E	1E	1E	4E	2E
Topographic position										
Slope, degrees	29°	10°	25°	2°	35°	17°	26°	32°	16°	26°
Aspect, degrees	12°	271°	330°	166°	231°	320°	334°	300°	312°	18°
Elevation, m	1813	2040	1737	1935	1913	1768	1958	1852	1829	1957
Coverage, % / Frequency, %	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F	C / F
SHRUBS										
Amelanchier alnifolia	0.7 / 6.0	+ / 2.0	.	.	.	*	+ / 2.0	+ / 2.0	.	+ / 2.0
Arctostaphylos uva-ursi	+ / 4.0	2.2 / 22.	4.0 / 30.	3.7 / 32.	.	+ / 10.	1.3 / 2.0	0.7 / 6.0	7.1 / 38.	.
Berberis repens	2.8 / 34.	4.5 / 50.	7.2 / 72.	+ / 4.0	4.9 / 48.	+ / 2.0	4.2 / 30.	11. / 80.	.	.
Betula occidentalis	.	.	.	.	.	*	.	.	.	.
Cornus canadensis	+ / 4.0	.	.	.	.	.	.	.	.	.

Table A-10, cont'd.

Stand Number	47	46	9	51	48	15	40	52	50	60
Juniperus communis	6.2 / 36.	14. / 46.	11. / 42.	8.5 / 18.	.	5.2 / 38.	17. / 46.	10. / 34.	+ / 4.0	1.1 / 6.0
Linnaea borealis	11. / 76.	.	.	.	19. / 70.	11. / 54.	36. / 96.	6.4 / 28.	24. / 66.	19. / 78.
Lonicera dioica	*	.	.	.	+ / 2.0	*	0.6 / 4.0	0.6 / 4.0	+ / 2.0	.
Prunus virginiana	.	.	.	.	.	.	.	*	.	.
Pyrola secunda	+ / 4.0	+ / 6.0	0.2 / 16.	.	2.2 / 26.	*	1.6 / 32.	+ / 4.0	.	1.2 / 16.
Pyrola virens	.	.	.	.	0.9 / 24.	.	+ / 10.	.	.	
Ribes setosum	.	.	.	.	.	.	.	.	*	.
Rosa acicularis	2.4 / 34.	1.0 / 12.	1.1 / 34.	1.4 / 26.	4.6 / 46.	+ / 6.0	5.7 / 58.	+ / 4.0	5.4 / 64.	1.6 / 16.
Rubus idaeus	.	.	.	.	*	.	.	.	.	.
Salix scouleriana	.	+ / 2.0	.	.	.	.	.	.	.	.
Shepherdia canadensis	*	3.7 / 6.0	*	.	.	+ / 2.0	1.8 / 14.	+ / 2.0	1.6 / 14.	.

Table A-10, cont'd.

Stand Number	47	46	9	51	48	15	40	52	50	60
Spiraea betulifolia	13./68.	7.3/52.	5.5/62.	6.3/56.	.	4.2/58.	.	*	.	.
Symphoricarpos albus	+/14.	+/6.0	.	+/4.0	1.3/14.	+/6.0	+/8.0	2.0/28.	0.8/12.	1.0/10.
Vaccinium scoparium	2.3/30.	4.7/100	18./70.	58./86.	17./58.	.	.	.	.	.
FORBS										
Achillea millefolium	+/10.	+/2.0	+/4.0	+/2.0	.	+/6.0	+/4.0	+/4.0	.	.
Aconitum columbianum	*	.	.	*	2.6/18.	.	.	.	*	.
Actaea rubra	.	.	.	.	*	.	*	.	.	.
Anaphalis margaritacea	.	.	.	0.8/4.0	.	.	.	.	.	.
Anemone cylindrica	.	.	.	.	.	.	.	+/8.0	.	.
Anemone multifida	+/10.	.	.	.	+/2.0	.	.	.	.	.
Anemone sp.	.	.	.	.	.	+/6.0	+/2.0	.	.	.

Table A-10, cont'd.

Stand Number	47	46	9	51	48	15	40	52	50	60
Antennaria plantaginifolia	0.6 / 12.	1.7 / 10.	.	1.0 / 12.	+ / 4.0	4.0 / 32.	+ / 2.0	*	0.7 / 8.0	.
Apocynum androsaemifolium	.	1.5 / 20.	.	.	.	.	.	.	+ / 18.	.
Aquilegia canadensis	.	.	.	.	*	.	.	.	.	*
Arenaria lateriflora	.	+ / 4.0	.	.	.	.	.	.	.	.
Arnica cordifolia	.	.	.	.	+ / 2.0	*	+ / 4.0	+ / 6.0	.	.
Arnica rydbergii	0.8 / 4.0	.	.	.	.	.	.	+ / 4.0	.	.
Aster ciliolatus	.	1.0 / 8.0	.	.	5.0 / 28.	.	*	+ / 2.0	.	.
Astragalus alpinus	.	.	.	.	.	0.6 / 12.	.	.	0.9 / 8.0	.
Campanula rotundifolia	0.7 / 6.0	0.8 / 10.	.	1.0 / 10.	*	+ / 2.0	.	.	*	.
Castilleja sulphurea	1.2 / 16.	*	.	.	*	.	+ / 2.0	.	.	.
Cirsium sp.	.	.	.	.	.	.	.	.	+ / 2.0	.

Table A-10, cont'd.

Stand Number	47	46	9	51	48	15	40	52	50	60
Clematis tenuiloba	10./74.	.	1.2/28.	.	2.7/28.	.	7.9/72.	1.0/18.	.	.
Corallorhiza maculata	.	*	.	*	.	*	.	.	.	.
Disporum trachycarpum	+/4.0	.	+/4.0	.	+/2.0	.	.	1.6/6.0	.	.
Dodecatheon pauciflorum	+/4.0	.	.	.	.	0.7/8.0	.	.	.	.
Epilobium angustifolium	.	*	.	.	+/2.0	.	*	.	0.6/12.	.
Fragaria virginiana	0.7/26.	+/2.0	0.8/20.	+/6.0	2.1/44.	1.4/24.	6.8/64.	+/10.	2.8/42.	1.6/12.
Galium boreale	1.2/18.	0.8/20.	+/4.0	+/2.0	2.3/32.	.	4.7/40.	+/12.	+/2.0	0.6/6.0
Galium triflorum	.	.	.	.	0.7/6.0	.	.	.	.	.
Gentianella amarella	.	.	.	*	*	.	.	.	+/4.0	.
Geranium richardsonii	.	.	.	.	*	.	.	.	.	.
Goodyera oblongifolia	+/4.0	.	.	.	.	.	.	.	.	.

Table A-10, cont'd.

Stand Number	47	46	9	51	48	15	40	52	50	60
Goodyera repens	+/10.	.	+/6.0	+/4.0	.	.	.	.	.	.
Habenaria viridis	1.0/10.	.	.	.	.	+/2.0	.	.	+/4.0	.
Halenia deflexa	+/6.0	.	.	.	+/14.	.	.	.	0.7/26.	.
Hedysarum alpinum	.	.	0.6/14.	*	0.7/8.0	+/2.0	+/4.0	+/2.0	1.5/18.	.
Heuchera richardsonii	.	.	.	.	*	+/8.0	.	.	+/10.	.
Hieracium albiflorum	.	.	.	2.2/26.	.	.	.	.	.	.
Hieracium umbellatum	2.8/22.	+/8.0	.	+/2.0	+/4.0	.	.	*	.	.
Lathyrus ochroleucus	0.6/12.	5.9/32.	+/10.	+/6.0	2.1/24.	+/4.0	1.8/12.	.	+/2.0	.
Lichens and mosses[a]	17./68.	+/4.0	.	12./40.	30./84.	16./64.	18./58.	10./48.	17./84.	24./72.
Lilium philadelphicum	.	.	.	.	.	*	.	.	.	.

Table A-10, cont'd.

Stand Number	47	46	9	51	48	15	40	52	50	60
Lupinus argenteus	+/2.0	.	.	*	.	+/2.0	.	.	.	.
Maianthemum canadense	.	0.9/16.	.	.	.	.	.	.	1.5/40.	.
Monarda fistulosa	.	+/4.0	.	.	.	.	.	.	.	.
Osmorhiza chilensis	.	.	.	.	2.1/26.	.	+/4.0	.	.	3.2/28.
Osmorhiza sp.	.	.	*	+/2.0	.	.	.	.	.	.
Oxytropis campestris	.	.	.	.	.	*	.	.	.	.
Phlox alyssifolia	.	.	.	.	.	+/4.0	.	.	.	.
Polygala senega	+/2.0	.	.	.	.	.	.	.	.	.
Potentilla gracilis	.	.	.	.	+/2.0	.	.	.	.	.
Pteridium aquilinum	.	.	.	14./40.	.	.	.	.	.	.

Table A-10, cont'd.

Stand Number	47	46	9	51	48	15	40	52	50	60
Rudbeckia hirsuta	+/10.	.	.	.	.	.	.	.	.	.
Senecio plattensis	+/10.	.	.	.	0.8/12.	+/6.0	+/2.0	.	+/18.	.
Smilacina stellata	.	+/2.0	.	.	3.5/34.	.	.	1.4/8.0	.	*
Solidago sp.	.	0.6/14.	.	.	.	.	.	.	.	.
Swertia radiata	2.3/22.	.	.	.	1.0/10.	.	1.0/4.0	.	.	+/2.0
Taraxacum officinale	.	.	+/8.0	.	1.3/10.	+/6.0	1.0/12.	*	.	.
Thalictrum dioicum	+/4.0	+/6.0	.	0.6/4.0	+/2.0	.	.	+/4.0	.	.
Trifolium repens	*	.	.	.	.	0.8/4.0	.	.	.	.
Valeriana edulis	.	.	.	.	*	.	.	.	.	.
Vicia americana	*	0.7/6.0	.	.	.	.	0.7/6.0	.	.	.
Viola adunca	+/10.	+/4.0	.	+/2.0	+/8.0	+/8.0	+/2.0	2.4/26.	+/4.0	.
Viola renifolia	.	.	.	.	.	.	.	.	0.7/16.	.

Table A-10, cont'd.

Stand Number	47	46	9	51	48	15	40	52	50	60
Zigadenus elegans	2.0/20.	.	0.6/14.	.	+/4.0	.	2.5/22.	+/4.0	+/2.0	.
Zizia aptera	.	.	.	.	.	.	.	.	.	0.6/12.
GRAMINOIDS										
Bromus inermis	.	.	.	.	.	.	1.9/14.	.	.	.
Carex concinna	1.5/18.	4.0/28.	.	.	1.3/10.	.	0.7/6.0	4.3/20.	.	.
Carex foenea	.	+/6.0	.	5.0/26.	.	.	.	0.7/8.0	3.1/28.	.
Carex microptera	.	0.5/10.	.	+/4.0	.	+/8.0	.	.	1.2/14.	+/2.0
Carex sp.	.	.	.	.	*	+/2.0	.	.	.	.
Danthonia spicata	.	1.9/26.	.	3.3/24.	.	.	.	.	.	.
Elymus innovatus	.	.	.	+/4.0	.	.	.	.	.	.
Festuca ovina	.	.	.	.	.	.	0.8/2.0	.	.	.
Oryzopsis asperifolia	12./62.	+/8.0	2.0/30.	3.3/26.	10./48.	1.0/22.	12./50.	6.5/30.	.	5.0/30.

Table A-10, cont'd.

Stand Number	47	46	9	51	48	15	40	52	50	60
Oryzopsis pungens	.	.	.	.	.	+/6.0	.	.	0.7/8.0	.
Poa interior	+/8.0	.	0.5/14.	.	.	.	+/4.0	.	*	.
Poa ovina	.	.	*	.	+/4.0	.	.	0.7/10.	.	.
Poa pratensis	1.6/14.	*	0.5/24.	+/10.	3.5/26.	+/2.0	3.2/18.	+/4.0	4.6/28.	.
Schizachne purpurascens	.	.	.	.	1.5/10.	.	5.7/20.	.	4.2/22.	.
Species in microplots	41	34	20	28	38	31	36	30	31	14
Coverage of shrubs[b]	39	38	47	78	50	21	69	32	39	24
Coverage of forbs[b]	44	16	4	33	59	26	46	18	28	30
Coverage of graminoids[b]	15	7	3	12	17	2	25	12	14	5
Total coverage	98	61	54	123	126	49	140	62	81	59

[a] In summing species in microplots mosses and lichens are counted as one forb in each stand where they occurred.

[b] In calculating coverage sums + is taken to be 0.2%.

Table A-11. Edaphic characteristics of the upper dm of mineral soil of each stand sampled. Data are listed by habitat type. C.E.C. is cation exchange capacity; B.S. is base saturation.

		Exchangeable Bases, meq/100 g			C.E.C. meq /	B.S.	Organic Matter	P	Particle Size Analysis % Sand	% Silt	% Clay	pH Lime requirement
Stand	pH	Ca	Mg	K	100 g	%	%	ppm		(textural name)		kg / ha
							Picea glauca / *Vaccinium scoparium* h.t.					
47	6.9	16.1	9.8	0.38	26.28	100.00	7.7	11.3	35.8	46.2	18.0	--
										(loam)		
46	5.3	10.2	3.1	0.40	17.30	79.19	7.4	31.2	31.5	54.9	13.6	4032
										(silt loam)		
9	5.5	15.2	6.6	0.31	22.31	99.10	5.3	11.9	17.3	52.8	29.9	224
										(silty clay loam)		
51	4.9	3.9	1.6	0.30	6.00	96.67	2.3	10.6	51.9	38.1	10.0	224
										(loam)		
48	6.3	17.5	9,6	0.31	27.41	100.00	5.8	12.3	24.3	51.4	24.3	--
										(silt loam)		
							Picea glauca / *Linnaea borealis* h.t.					
15	6.1	9.8	3.8	0.38	13.98	100.00	7.3	33.1	44.3	47.2	8.5	--
										(loam)		
40	6.4	20.9	6.6	0.30	27.80	100.00	8.2	11.7	31.1	49.2	19.7	--
										(loam)		
52	7.3	22.0	9.1	0.37	31.47	100.00	10.5	16.2	37.7	47.7	14.6	--
										(loam)		
50	5.4	6.3	1.7	0.35	8.35	100.00	2.7	11.5	46.7	39.1	14.2	--
										(loam)		
60	6.9	14.3	7.5	0.32	22.12	100.00	8.52	17.9	36.4	49.2	14.4	--
										(loam)		

Table A-11, cont'd.

Stand	pH	Exchangeable Bases, meq/100 g Ca	Mg	K	C.E.C. meq / 100 g	B.S. %	Organic Matter %	P ppm	Particle Size Analysis % Sand	% Silt (textural name)	% Clay	pH Lime requirement kg / ha
					Populus tremuloides / Corylus cornuta h.t.							
67	5.6	7.8	2.4	0.45	11.85	89.87	7.20	21.4	52.9	36.7 (sandy loam)	10.4	1344
69	5.7	6.3	2.1	0.40	9.00	97.78	5.84	42.0	48.4	45.2 (sandy loam)	6.4	224
55	5.5	5.5	2.2	0.36	8.06	100.00	2.2	33.3	23.4	59.1 (silt loam)	17.5	--
2	6.0	9.2	2.3	0.44	11.94	100.00	4.0	41.8	49.2	42.7 (loam)	8.1	--
30	5.9	7.8	2.6	0.32	10.72	100.00	3.4	25.0	26.7	58.4 (silt loam)	14.9	--
31	5.7	9.9	2.6	0.44	14.14	91.51	5.4	36.7	28.9	52.8 (silt loam)	18.3	1344
					Populus tremuloides / Corylus cornuta h.t., *Pteridium aquilinum* phase							
25	6.0	19.9	4.9	0.41	25.41	99.21	8.5	33.3	30.0	51.7 (silt loam)	18.3	224
26	5.5	16.3	3.7	0.55	25.55	80.43	8.7	46.5	19.8	59.9 (silt loam)	20.3	5600
					Populus tremuloides / Corylus cornuta h.t., *Aralia nudicaulis* phase							
43	6.2	11.2	3.6	0.39	15.19	100.00	5.2	24.4	39.6	41.1 (loam)	19.3	--

Table A-11, cont'd.

Stand	pH	Exchangeable Bases, meq/100 g Ca	Mg	K	C.E.C. meq / 100 g	B.S. %	Organic Matter %	P ppm	Particle Size Analysis % Sand	% Silt	% Clay	(textural name)	pH Lime requirement kg / ha
Pinus ponderosa / *Juniperus communis* h.t.													
1	6.3	17.6	11.1	0.47	29.17	100.00	9.70	19.5	51.4	29.6	19.0	(loam)	--
5	6.5	8.3	5.3	0.42	14.02	100.00	5.14	23.0	46.5	36.6	16.9	(loam)	--
7	6.0	5.5	4.5	0.36	10.36	100.00	4.58	30.0	43.6	27.6	28.8	(clay loam)	--
8													
29	6.5	18.7	11.5	0.36	30.56	100.00	9.36	16.5	42.5	35.5	22.0	(loam)	--
38	5.1	10.1	3.6	0.35	16.05	87.54	6.94	16.5	22.0	53.2	24.8	(silt loam)	2240
53	5.3	8.2	3.3	0.37	13.07	90.82	8.26	49.8	58.6	34.5	6.9	(sandy loam)	1344
Pinus ponderosa / *Arctostaphylos uva-ursi* h.t.													
16	5.5	7.8	3.0	0.34	11.14	100.00	10.30	27.2	37.7	51.3	11.0	(silt loam)	--
17	5.3	5.5	0.7	0.31	6.51	100.00	4.54	27.0	44.4	41.4	14.2	(loam)	--
18	4.9	5.4	2.1	0.32	9.82	79.63	8.98	42.2	43.6	43.4	13.0	(loam)	2240

Table A-11, cont'd.

Stand	pH	Exchangeable Bases, meq/100 g Ca	Mg	K	C.E.C. meq / 100g	B.S. %	Organic Matter %	P ppm	Particle Size Analysis % Sand	% Silt	% Clay	(textural name)	pH Lime requirement kg / ha
19	4.7	3.1	2.1	0.31	5.71	96.50	4.56	40.0	47.6	43.4	9.0	(loam)	224
34	6.7	24.2	3.8	0.35	28.35	100.00	9.54	12.8	46.4	33.5	20.1	(loam)	--
37	5.5	6.3	3.9	0.34	10.74	98.14	6.16	27.0	30.6	52.2	17.2	(silt loam)	224
41	6.2	16.5	8.4	0.40	25.30	100.00	8.84	19.3	25.0	47.3	27.7	(clay loam)	--
62	5.4	4.8	1.6	0.24	6.64	100.00	2.00	19.9	48.4	39.6	12.0	(loam)	--
66	5.2	2.9	1.7	0.28	6.08	80.26	4.66	24.2	73.4	22.2	4.4	(sandy loam)	1344
70	5.5	5.0	2.4	0.35	7.75	100.00	4.04	19.3	48.9	43.7	7.4	(loam)	--
						Pinus ponderosa / *Physocarpus monogynus* h.t.							
57	6.5	25.3	4.3	0.40	30.00	100.00	11.34	21.8	37.7	41.4	20.9	(loam)	--
64	7.1	15.6	6.8	0.29	22.69	100.00	7.18	12.7	50.4	38.6	11.0	(loam)	--
65	7.1	13.9	6.8	0.31	21.01	100.00	4.52	17.7	43.9	36.7	19.4	(loam)	--

Table A-11, cont'd.

Stand	pH	Exchangeable Bases, meq/100 g Ca	Mg	K	C.E.C. meq / 100g	B.S. %	Organic Matter %	P ppm	Particle Size Analysis % Sand	% Silt (textured name)	% Clay	pH Lime requirement kg / ha
Pinus ponderosa / Carex heliophila h.t.												
49	4.8	4.3	2.2	0.35	8.85	77.40	4.54	27.8	46.6	28.6 (loam)	24.8	2240
23	5.4	5.8	3.1	0.13	9.03	100.00	4.74	12.3	46.6	32.5 (loam)	20.9	--
63	5.8	4.4	0.9	0.18	5.48	100.00	1.52	12.8	78.4	17.6 (loamy sand)	4.0	--
Pinus ponderosa / Juniperus scopulorum h.t.												
58	7.3	11.4	2.9	0.24	14.54	100.00	6.90	9.9	70.4	26.6 (sandy loam)	3.0	--
Pinus ponderosa / Quercus macrocarpa h.t.												
28	6.0	11.1	4.8	0.33	16.23	100.00	9.50	36.7	54.7	31.5 (sandy loam)	13.8	--
27	5.3	12.6	3.6	0.40	17.80	93.26	7.78	29.1	25.7	41.4 (clay loam)	32.9	--
44	5.4	4.9	1.7	0.24	6.84	100.00	4.96	24.0	65.1	29.1 (sandy loam)	5.8	1344
68	6.9	11.1	1.7	0.26	13.06	100.00	4.58	9.7	67.4	24.2 (sandy loam)	8.4	--
Pinus ponderosa / Symphoricarpos albus h.t.												
12	6.6	11.1	5.8	0.32	17.22	100.00	7.16	13.7	49.6	29.6 (loam)	20.8	--

Table A-11, cont'd.

Stand	pH	Exchangeable Bases, meq/100 g Ca	Mg	K	C.E.C. meq / 100g	B.S. %	Organic Matter %	P ppm	Particle Size Analysis % Sand	% Silt (textured name)	% Clay	pH Lime requirement kg / ha
14	5.8	9.3	3.2	0.42	12.92	100.00	8.52	29.0	44.3	47.2 (loam)	8.5	--
21	5.4	8.8	2.7	0.32	12.02	98.34	8.12	17.7	41.7	45.3 (loam)	13.0	224
39	6.5	20.0	8.8	0.36	29.16	100.00	16.56	16.6	53.5	31.5 (sandy loam)	15.0	--
42	7.0	16.8	4.7	0.37	21.87	100.00	8.32	13.0	52.7	33.5 (sandy loam)	13.8	--
54	5.3	6.4	2.6	0.49	9.69	97.94	7.74	31.0	45.6	39.4 (loam)	15.0	224
59	6.1	8.5	3.8	0.37	12.67	100.00	6.34	10.8	42.4	47.2 (loam)	10.4	--
		Pinus ponderosa / *Symphoricarpos* albus h.t., *Oryzopsis asperifolia* phase										
24	5.0	8.4	3.1	0.36	13.86	85.57	11.28	29.1	69.5	23.2 (sandy loam)	7.3	2240
32	5.1	4.9	2.7	0.30	8.10	97.53	6.60	22.0	63.4	27.6 (sandy loam)	9.0	224
6	6.0	10.7	2.3	0.36	13.36	100.00	6.16	36.1	27.9	45.3 (loam)	26.8	--

Table A-11, cont'd.

Stand	pH	Exchangeable Bases, meq/100 g Ca	Mg	K	C.E.C. meq / 100g	B.S. %	Organic Matter %	P ppm	Particle Size Analysis % Sand	% Silt (textured name)	% Clay	pH Lime requirement kg / ha
		Pinus ponderosa / *Symphoricarpos albus* h.t., *Balsamorhiza sagittata* phase										
13	5.8	9.9	5.1	0.37	15.37	100.00	7.86	21.2	33.8	55.2 (silt loam)	11.0	--
61	7.0	11.8	2.2	0.29	14.29	100.00	3.46	10.8	49.4	36.2 (loam)	14.4	--
		Quercus macrocarpa / *Symphoricarpos occidentalis* h.t.										
3	6.0	16.3	2.5	0.71	19.71	98.99	7.2	36.3	36.1	43.1 (loam)	20.8	224
		Quercus macrocarpa / *Ostrya virginiana* h.t.										
45	7.4	11.5	2.6	0.41	14.51	100.00	4.2	17.0	52.8	31.0 (sandy loam)	16.2	--
11	6.1	1.5	0.7	0.31	2.51	100.00	3.7	24.7	65.5	24.7 (sandy loam)	9.8	--
10	5.8	7.9	2.0	0.33	10.23	100.00	3.6	25.2	62.6	29.4 (sandy loam)	8.0	--
4	5.6	11.5	2.1	0.37	14.17	98.59	4.2	29.0	32.0	43.6 (loam)	24.4	224
20	6.7	16.8	4.5	0.46	21.76	100.00	8.5	36.3	39.1	32.5 (clay loam)	28.4	--

Table A-11, cont'd.

Stand	pH	Exchangeable Bases, meq/100 g			C.E.C. meq / 100g	B.S. %	Organic Matter %	P ppm	Particle Size Analysis			pH Lime requirement kg / ha
		Ca	Mg	K					% Sand	% Silt (textured name)	% Clay	
				Cercocarpus montanus / *Bouteloua curtipendula* h.t.								
35	7.8	10.0	2.5	0.30	12.80	100.00	1.2	8.4	30.1	33.5	36.4	--
										(clay loam)		
36	7.8	14.4	0.7	0.27	15.37	100.00	3.2	8.8	48.9	33.0	18.1	--
										(loam)		
56	7.6	18.6	1.6	0.40	20.60	100.00	5.5	11.1	51.9	38.1	10.0	--
										(loam)		

Table A-12. Mean temperature (T) and precipitation (P) data from selected weather stations in and near the Black Hills. Sites Sundance through New Castle are located about the periphery of the Hills; sites Deadwood through Elk Mountain are located in the Hills. Sites within the Hills are listed generally from north to south. Data are from U.S. Dept. of Agr. (1933) and U.S. Dept. of Commerce (1960).

	Jan		Feb		Mar		Apr		May		June		July		Aug		Sept		Oct		Nov		Dec		Ann	
	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P
	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm
Sundance, 1454 m	--	18.8	--	15.6	--	29.0	--	43.2	--	64.8	--	85.9	--	42.2	--	27.7	--	35.1	--	25.2	--	19.8	--	17.5	--	425.
Belle Fourche, 920 m	-5.5	6.60	-4.2	5.80	-0.3	16.3	+7.7	47.2	+13.	53.3	+18.	80.0	+23.	33.8	+21.	30.7	+16.	30.0	+9.5	19.6	+1.7	10.7	-3.3	5.60	+8.1	340.
Spearfish, 9 WNW, 1112 m	--	15.2	--	13.0	--	24.9	--	57.1	--	91.7	--	42.2	--	35.8	--	39.9	--	24.1	--	18.8	--	12.7	--	12.7	--	445.
Fort Meade, 1006 m	-4.2	14.2	--	18.0	--	39.1	--	50.3	--	117.	--	90.9	+22.	76.0	--	50.0	--	33.3	--	31.0	--	11.4	--	17.5	--	549.
Rapid City, 957 m	-4.2	10.7	-2.9	10.9	+0.1	27.4	+7.6	50.8	+13.	70.4	+18.	87.6	+24.	47.0	+22.	42.4	+17.	24.9	+11.	24.1	+2.9	9.90	-1.7	7.90	+8.9	414.
Hermosa, 1006 m	-5.6	8.60	--	7.90	--	17.8	--	41.0	--	98.6	--	82.0	+22.	67.3	--	53.1	--	36.6	--	27.2	--	9.90	--	11.7	--	462.
Hot Springs, 1111 m	-3.8	10.4	-2.3	13.2	+1.3	28.5	+8.2	48.5	+14.	77.2	+19.	76.5	+24.	53.9	+23.	43.4	+17.	33.8	+11.	19.6	+2.7	9.40	-1.7	9.10	+9.3	423.
New Castle, 1316 m	-4.9	11.4	-3.1	9.10	+0.1	20.6	+7.1	36.6	+13.	58.9	+18.	65.3	+24.	39.6	+22.	43.2	+16.	22.9	+9.7	21.1	+1.6	11.9	-1.7	10.4	+8.3	351.

Table A-12, cont'd.

Station	Jan T °C	Jan P mm	Feb T °C	Feb P mm	Mar T °C	Mar P mm	Apr T °C	Apr P mm	May T °C	May P mm	June T °C	June P mm	July T °C	July P mm	Aug T °C	Aug P mm	Sept T °C	Sept P mm	Oct T °C	Oct P mm	Nov T °C	Nov P mm	Dec T °C	Dec P mm	Ann T °C	Ann P mm
Deadwood, 1382 m	+1.6	29.2	+1.6	26.4	+7.3	58.2	+12.	96.0	+17.	116.	+24.	93.7	+27.	98.6	+26.	63.2	+21.	59.4	+14.	52.3	+7.7	32.5	+2.0	36.6	+14.	762
Lead, 1621 m	-4.3	28.2	-3.5	22.1	-1.3	43.2	+5.2	75.2	+11.	99.1	+16.	104.	+11.	52.8	+20.	42.7	+15.	39.9	+8.9	33.5	+1.3	29.0	-2.2	24.1	+7.2	594
Dumont 2 ENE, 1890 m	--	35.2	--	22.1	--	44.2	--	64.3	--	84.1	--	90.4	--	53.9	--	44.7	--	35.1	--	28.7	--	31.2	--	24.9	--	559
Greenmont, 1932 m	--	35.6	--	33.0	--	43.2	--	87.6	--	87.1	--	78.7	--	72.4	--	65.0	--	41.7	--	42.9	--	31.8	--	34.5	--	654
Hardy Ranger Station, 2012 m	--	42.9	--	30.7	--	39.4	--	50.5	--	60.5	--	69.1	--	57.7	--	46.2	--	42.9	--	41.2	--	26.9	--	31.5	--	539
Harveys Ranch, 1915 m	--	40.9	--	34.3	--	46.2	--	62.5	--	64.1	--	103.	--	91.4	--	58.4	--	38.9	--	35.8	--	28.7	--	25.9	--	651
Buskala Ranch, 1859 m	--	32.2	--	22.1	--	44.7	--	79.0	--	102.	--	108.	--	65.8	--	45.7	--	37.6	--	32.0	--	28.2	--	24.9	--	622
Rochford, 1609 m	--	21.8	--	18.3	--	28.5	--	55.1	--	74.7	--	80.3	--	72.6	--	57.7	--	35.3	--	32.5	--	20.6	--	17.5	--	515
Silver City, 1524 m	--	18.0	--	23.4	--	50.0	--	58.2	--	88.9	--	104.	--	60.7	--	44.5	--	33.3	--	15.5	--	22.4	--	16.3	--	535
Deerfield, 1829 m	--	15.0	--	10.4	--	19.8	--	44.7	--	67.6	--	84.8	--	74.7	--	54.9	--	35.0	--	27.9	--	14.5	--	10.2	--	459

Table A-12, cont'd.

Jan		Feb		Mar		Apr		May		June		July		Aug		Sept		Oct		Nov		Dec		Ann	
T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P	T	P
°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm	°C	mm
Custer, 1621 m																									
--	10.4	--	9.70	--	25.4	--	47.8	--	78.5	--	78.5	--	50.4	--	64.0	--	26.7	--	26.7	--	9.90	--	9.10	--	437.
Elk Mountain, 1432 m																									
--	15.8	--	11.7	--	15.8	--	33.3	--	49.8	--	69.1	--	67.1	--	43.2	--	38.9	--	26.9	--	16.8	--	13.0	--	401.